UNESCO – KALINGA PRIZE WINNER – 1967

Professor Sir Fred Hoyle, FRS

[Britain's Best Known Astromomer and Physicist who propounded the "Steady State" theory of the Universe and defended it energetically in defiance of Orthodox Cosmology]

[Born : June 24, 1915, Bingley, Yorkshire, England
Died : August 20, 2001, Bournemouth, Dorset, England]

The Universe does not respect the differences between Physics, Chemistry & Biology

..... Sir Fred Hoyle

"Every Cluster of galaxies, every star, every atom … had a beginning, but the universe, itself, did not."

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Sir Fred Hoyle (1915-2001)

Distinguished and controversial British astronomer, mathematician, popularizer of science, and novelist, who rejected the "big bang' theory. "Every cluster of galaxies, every star, every atom had a beginning, but the universe itself did not," Hoyle claimed. He coined the phrase "big bang" to mock the opposing model, according to which the universe originated from a spontaneous explosion. Hoyle also suggested that life had a cosmic, not terrestrial origin, and viruses could originate from certain meteor streams. He He supported the anthropic principle, holding that there is a design in creation: the universe was designed in such a way as to produce life. "Our existence dictates how the universe shall be," he stated, and added, "a fine ego-boosting point of view on which you may travel, fare paid, to conferences all over the world." Besides scientific works, Hoyle published many science fiction novels, written in collaboration with his son, Geoffrey Hoyle.

> **"The astronomer Fred Hoyle once remarked to me that it was pointless for the world to hold more people than one could get to know in a single lifetime. Even if one were president of United Earth, that would set the figure somewhere between ten thousand and one hundred thousand; with a very generous allowance for duplication , wastage, special talents, and so forth, there really seems no requirement for what has been called the global village of the future to hold moire than a million people scattered over the face of the planet." (Arthur C. Clarke in Greetings, Carbon-Based Bipeds, 1999)**

Fred Hoyle was born in Bingley, Yorkshire, as the son of a wool merchant and a teacher. He started to study stars early in his childhood. At the age of four he could write out the multiplication tables up to 12x2 = 144. By the age of thirteen, he had begun to read widely, from such books as *Arthur Eddington's Stars and Atoms* to T.E. Lawrence's *Seven Pillars of Wisdom.* However, instead of astronomy he first studied mathematics at Cambridge University's Emmanuel College. Hoyle received his B.A. in 1936 and his M.A. in physics from Cambridge in 1939. In the same year he married Barbara Clark; they had a son and a daughter. In 1939, under the influence of his colleague Raymond Lyttleton, Hoyle's interest started to shift from mathematical physics toward astrophysics. He had attended Eddington's lectures in 1935-36 and answered his questions on general relativity in examination.

Hoyle was elected a Fellow of St. John's College at Cambridge in 1939. During World War II Hoyle worked at the Admiralty Signals Establishment, later Admiralty Weapons Establishment, where he participated in the development of radar.During this period he met Hermann Bondi and Thomas Gold. With them he developed the revolutionary "continuous creation" theory or the "steady-state" cosmology. Hoyle's paper was published in the journal of the Royal Astronomical Society in 1948. Hoyle's *Nature of the Universe* (1950) introduced the theory to a wider audience. Although the "big bang"hypothesis was confirmed in 1960s and became a scientific paradigm, Hoyle continued to examine its weak points. The hypothesis had been introduced in the 1920s by Georges LeMaitre(1894-1966), a priest and cosmologist. When evolution theory had been a problem for the Catholic Church, the "big bang" was not – partly because it strongly supported the idea of creation.

In 1945 Hoyle became a junior lecturer in mathematics at the university of Cambridge. His three teaching terms took up less than twenty-five weeks of the year, and for the rest of the time he could pay attention to research. In 1946 he sent for publication to the Royal Asronomical Society two papers, the longer was "The Synthesis of the Elements from Hydrogen' and the shorter was 'Note on the Origin of Cosmic Rays', in which he predicted that heavy elements would be found in cosmic rays. The prediction ws confirmed twenty-two years later. For the BBC he made five lecture-type talks on astronomy, which were printed in *The Nature of the Universe.* The book was well received and the Hoyles celebrated the success by buying their first refrigerator.

In the 1950s Hoyle collaborated with William Alfred Fowler and Geoffrey and Margaret Burbidge in developing a theory on the origin of the elements, which earned Fowler the Noble Prize for physics in 1983. In 1957 they published I. *Synthesis of the Elements in Stars,* the first comprehensive account how the elemens are produced in the interior of stars. The "I" in the title meant that there would be a second paper. However, part II never appeared. Fowler has acknowledged his debt to Hoyle in his autobiography written for the Nobel Foundation: "Fred Hoyle was the second great influence in my life. The grand concept of nucleosynthesis in stars was first definitely established by Hoyle in 1946."

Hoyle was a staff member of the Mt. Wilson and Palomar Observatories from 1956 until 1965. In 1958 Hoyle became Plumian professor of Astronomy and Experimental Philosophy at Cambridge. The work took him to the top of the British astronomical establishment. One of his many achievements was the founding of the Institute of Theoretical Astronomy at Cambridge. It started in 1967 and Hoyle served as the first director. Hoyle also was vice president of the council of the Royal Society, president of the Royal Astronomical Society, member of the Science Research Council from 1967 to 1972, and a foreign member of the American Philosophical Society and of the National Academy of Sciences. Hoyle was knighted in 1972, at the age of 57, but at that time he felt he had had enough of the Cambridge system and resigned from his formal appointments in the UK. During this period he published one of his most pessimistic novels, *The Inferno* (1973), in which the nucleus of the Milky Way explodes. Cosmic particles cause a global disaster, wiping out nearly all human life. The protagonist is a physicist who represents the voice of reason in the world of insanity. He becomes the leader of a clan in Scotland. Hoyle's message is clear – scientists should rule the world in a time of crisis.

After leaving Cambridge Hoyle worked at the California Institute of Technology, and at Cornell. Hoyle's nomadic phase ended by the spring of 1977-Hoyle stayed outside the United Kingdom during these years mainly due to the tax laws of the Wilson government. The intervening years he spent partly in writing, in research, and partly in giving lectures. He published books on a wide variety of subjects, which were noted for their originality. Between the years 1975 and 1985 he examined the big problem of the origin of life. With Chandra Wickramasinghe, his former student, he wrote among others *Life cloud* (1978), on the origin of disease, and Diseases from Space (1979) and *Evolution from Space* (1981). In these works he argued that organic molecules from comets are deposited on Earth during close encounters or impacts, they join the gene pool and make evolution possible. *Copernicus* (1973) dealt with the history of astronomy. *From Stonehenge to Modern Cosmology* (1972) was about archeo – astronomy. Hoyle's autobiography, *Home Is where The Wind Blows*, appeared in 1994. In its last page he wrote: "After a lifetime of crabwise thinking, I have gradually become aware of the towering intellectual structure

of the world, One article of faith I have about it is that, whatever the end may be for each of us, it cannot be a bad one." Hoyle died in Bournemouth on August 20,2001.

In Hoyle's novels the heroes are scientist, who are opposed by politicians. Alien or cosmic intelligence is often beyond human comprehension, but also dangerously ignorant of the value of human life. In *The Black Cloud* (1957) a sentient cloud kills nonchalantly one quarter of the world's population. In *The Westminster Disaster* (1978) the buildings of Whitehall come "down life so many rotten fruit" after a terrorist attack. Scientists are not hindered by catastrophes in thaeir attempt to communicate with super-intelligence-they are objective and willing to learn the secrets of the universe. In *Ossian's Ride* (1959) the protagonist gladly joins aliens who plan to transform Earth into a high-tech world. In crisis politicians want to hide the truth from people and army officers react with missiles.

> "**Astronomy is kind in its treatment of the beginner. There are many jobs to be done, jobs that can lead to important results but which do not require great experience. Jensen's was one of these. He was searching for supernovae, stars that explode with uncanny violence. Within the next year he might reasonably hope to find one or two. Since there is no telling when an outburst might occur, nor where it the sky the exploding star mighbt be situated, the only thing to do was to keep on photographing the whole sky, night after night, month after month. Some day he would strike lucky." (from The Black Cloud)**

The Black Cloud dealt with one of Hoyle's favorite subjects – intelligent life in the universe. The story sarts in the year 1964. At Mt. Palomar Knut Jensen finds that a giant cloud of interstellar gas is approaching the solar system. Professor Chris Kingsley from Cambridge calculates that the cloud will come between the Sun and Earth, which will lead to a global catastrophe. Hoyle follows the work of the scientist and reactions of politicians who first want to keep the cosmic threat a secret. Hoyle's attitude to civilians is ironic; only the scientist can coolly analyze the situation. The effects of the cloud are disastrous when it arrives in the solar system. But it turns out that the cloud is alive, and it starts to communicate with the scientist-it has opinions about music, the roles of men and women, evolution, and the origin of headaches. When the governments of the United States and the Soviet Union try to destroy it with missiles, it sends them back. The cloud leaves the solar sysem, encouraging humankind to create more geniuses. – The story also aroused the interest of Wolfgang Pauli, the Nobel Laureate in Physics in 1945, who told once to Hoyle that he had studied it together with Carl Jung, who wrote a rcritical essay on it. "I didn't have the temerity to explain that I thought I was only writing a story. But I had an intelligent life form in the story that didn't think in words, a form that had to learn words before it could communicate with man. Pauli knew all about Schrödinger's cat, about arguments over the origins of mathematics, while Jung knew about human emotions. So it was evidently the problem of what lies behind words that had been occupying them." (from *Home is where the Wind Blows by Fred Hoyle,* 1997)

With John Elliot Hoyle co-wrote the BBC television serials *A for Andromeda* (1961) and *Andromeda Breakthrough* (1962), starring Julie Christie. In the story messages from the direction of the Andromeda galaxy contain a blueprint for making a female android. *Rockets in Ursa Major* (1962) was originally written for the Mermaid Theatre. In the story a rocket ship, launched to Ursa Major, returns without the crew, with a message from its captain:"If this ship returns to Earth, then mankind is in deadly peril-God help you –". Earth is drawn into a galactic war,

but with the help of human-like aliens, the world is saved, not evacuated.

> **"All other eating places were now completely automatized, choice remaining only in the different ways of ordering one's food, and I suppose the decor came into it. For instance, the inexpensive cafés are very simple. You sit at a long table with a moving panel in the middle. Having chosen from the menu list, you punch your choice and the food comes up within seconds on the moving panel. In more expensive restaurants there are separate tables. A microphone is used to order food. According to the advertisements, this is the personalized way." (from *Rockets in Ursa Major,* 1962)**

In *Fifth Planet* (1963) the year is 2087. A new solar system with a sun named Helios, approaches ours, but would not really disturb the orbital path of the Earth. The Euro-American and Communist blocks launch rival rocketship expeditions to explore Achilles, the planet of Helios. The western crew, professor Hugh Conway, Mike Fawsett and two other members, lose the race-the Russians land first, but unluckily. The planet is Earth-like with its atmosphere and green hills. In the spirit of détente the crews work together and find a strange transparent construction, but not much else. An alien returns to Earth in the body of Fawsett, and then takes the body of Cathy, Conway's wife, telling him the secret of cosmic lifebank. Conway accepts the marriage of human and alien mind. A global hallucination of the nuclear war shocks the world. Conway escapes to the grassy wandering planet with Cathy, carrying the homesick alien.

For further reading: Origins: The Lives and Worlds of Modern Cosmologists by Alan Lightman and Roberta Brawer (1990); The Encyclopedia of Science Fiction, ed. by John Clute and Peter Nicholls (1993) –
For further information : Fred Hoyle-Sir Fred Hoyle – **An interview with Fred Hoyle,** Cambridge, England, 5 July 1996-**Physics Today –** The Bruce Medalists – Fred Hoyle's The Intelligent Universe

Note : Arthur C. Clarke has prophesied that in the year 2061 first humans land on Halley's Comet, and the discovery of both dormant and active life-forms vindicates Hoyle and Wikramasinghe's hypothesis that life is omnipresent throughout space.

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- **Rockets in Ursa Major,** 1962 (play for children)
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- **The Energy Pirate,** 1982 (the Professor Gamma series, with Geoffrey Hoyle)
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- **The Planet of Death,** 1982 (the Professor Gamma series, with Geoffrey Hoyle)
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- **Cosmic Lifeforce,** 1988 (with C. Wickramasinghe)
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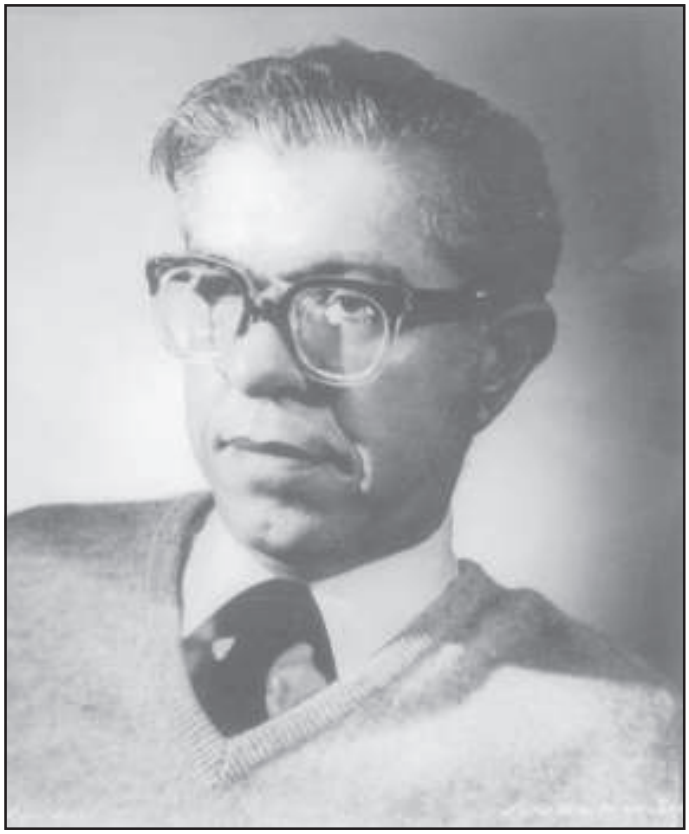
SIR FRED HOYLE, FRS

Biographical Memoirs



[24 June 1915--------20 August 2001]

PROCEEDINGS OF THE AMERICAN PHILOSOPHICAL SOCIETY VOL. 147, NO. 4, DECEMBER 2003

Biographical Memoirs

SIR FRED HOYLE was born on 24 June 1915, in the village of Gilstead, near Bingley, in the northern English country of Yorkshire. His parents, grandparents, and earlier forbears were all north-country hard-working people, with many talents but no money except what they earned. His father, Ben Hoyle, and his mother, née Mabel Pickard, were cousins; Mabel had considerable musical talent, and Fred's love of music was surely inherited from here.

Fred was responsible for the most profound advances that have been achieved in our understanding of the formation, structure, energy sources, and final demise of stars in our galaxy, the Milky Way. From stars to galaxies to the large-scale structure of the Universe, Fred's researches included his fundamental work in cosmology, in which he was one of the threee proponents of a "steady-state cosmology," which I will describe later, and of the "quasi-steady-state cosmology", described in his last book published in 2000 with coauthors Geoffrey Burbidge and Jayant Narlikar. Today's understanding of the building of the chemical elements from the lightest, hydrogen, to the heaviest, uranium, during the lifetime of stars will always be linked to Fred Hoyle's fundamental work.

FAMILY BACKGROUND :

Fred Hoyle's father enlisted in the British army soon after the start of World War I (1914-18, the "Great War") , and shortly after Fred's birth in June 1915. Ben became the leader of a machine gun unit, and he must have had considerable strategic common sense, to have surived the terrible carnage of those years among the ground troops. In his autobiography, *Home is were the Wind Blows,* Fred described his father's account of how he and one other soldier survived a heavy enemy attack in the spring of 1918. Fred's mother, to supplement the meager soldier's pay, and with her considerable musical talent, took a job playing the piano at the local cinema to accompany the silent films. She played Beethoven sonatas, which the audience apparently enjoyed at least as much as the movies.

EARLY YEARS : SCHOOLS IN NORTH YORKSHIRE :

The Small World of Fred Hoyle, his own account of his life up until his marriage to Barbara Clark in 1939, was published in 1986. The walks to and from the Mornington Road children's school, over muddy streets, through whatever the skies presented, wearing shoes worn into holes and unprotective against rain or snow, were endured until a fascinating contretemps with the teacher occurred,as described in his autobiography. A lesson on flowers was being given; the children had been asked to collect a number of samples. Fred had one in his hand, and the teacher was describing this species as having five petals. Unfortunately, Fred's flower, I suppose a sport, had six petals. When Fred pointed this out, while the teacher kept insisting that five was the correct number, she apparently lost her temper and slapped him very hard on the side of his head. This was the end of school for a while; concluding that the teacher was apparently unable to count up to six, Fred became a truant and carried on some practical education by himself.

The Leeds and Liverpool Canal passes through Bingley, and Fred the truant spent many hours studying the workings of the "five-rise locks" just outside Bingley. A few yeas later, he found a textbook on chemistry among his parents' few books, and proceeded to carry out some of the experiments in the scullery of their house. His description of his quest, at age ten and a half, to the local chemist's shop to buy what he need for experiments described in the book, asking "Does

'ta' ave any glass tubing?" "Does 'ta' ave any concentrated sulfuric acid? H_2SO_4, tha knaws," and proceeding to make phosphine as described in the book, is one I can read and reread with delight.

Fred's mother had ambition for Fred, however, and attendance at the grammar school in Bingley was necessary if he was to get anywhere in his life. To achieve this, a primary school was necessary. The nearby village of Eldwick had a small school, and Fred was enrolled there; he did well (no teacher who could not count up to six!) and he won a scholarship that took him to Bingley grammar school in September 1926. The headmaster there, Alan Smailes, was a teacher who knew his business, and prepared Fred and one other boy for the Cambridge scholarship exam. While he did not win financial support, Fred did win a Yorkshire scholarship, and acceptance at Cambridge.

CAMBRIDGE, 1933-39 :

Emmanual College accepted the undergraduate Fred Hoyle, and his tutor there was the mathematician P. W. Wood. Three years later, on a hiking holiday with a fellow student, Fred received a telegram informing him of his success in the mathematical tripos, and that he had won a half-share of the Mayhew Prize, given for the best performance in applied mathematics.

Now entering as a research student in July 1936, Fred started working on an essay on b-decay, which won him the first (top) of the two Smith's Prizes awarded in the spring of 1938. Though I have not been able to discover the sum awarded, it was clearly a considerable boost to his finances.

Raymond Lyttleton, a little older than Fred, was at St. John's College,working in astrophysics, specifically the accretion of interstellar matter by stars as they move through the low-density gas that pervades the Galaxy. A meeting to arrange for Ray to give a talk on his research at one of the weekly seminars led to a close friendship and collaboration that lasted until Ray's death in 1995. Thus began the shift of Fred's scientific interest and research into astrophysics.

MARRIAGE AND WORLD WAR II :

In the late spring of 1939, Fred met Barbara Clark at a restaurant frequented by students, where she and another girl had been brought from a school in the north of England by a former mathematics student whom Fred knew from his undergraduate days. Barbara was there for an interview at Girton College, the college for women students on the outskirts of Cambridge (this was well before the barriers against women in the university were demolished!). As Fred described it in *Home Is Where the Wind Blows,* he knew instantly that his life partner had appeared on stage. They went on holiday in the summer of 1939, and were married on 28 December 1939.

World War II had startd for Britain on 3 September 1939, but for several months it appeared to be the "phony" war, with no immediate invasion of Britain as had been feared, and no immediate waves of bombers flying across the Channel to bomb the hell out of British airfields and demolish London.

Fred joined the naval radar research establishment at Nutbourne, a large field near Chichester where antennae for naval radar were designed. Barbara and their baby son, Geoffrey, accompanied him. He was joined by two men who had escaped Hitler's destruction of the Jews in Germany and Austria, had been interned in the panic rush to imprison all such young men as "enemy aliens," and had later been released to take part in war work. These were Hermann Bondi and Thomas Gold.

An early achievement by Fred that is not widely known concerns the radar being used by ships in the Royal Navy. The radar at that time used wavelengths of several meters, and could give the bearing of an attacking aircraft but not its height. Fred saw that the interference lobes of the radar aimed at aircraft, due to sea reflection, meant that the ranges at which the aircraft echo faded gave

away it height. The radar officer had just to plot the range of the first appearance of a plane and of its subsequent disappearance from the screen, thus identifying the position of the plane in the interference pattern between the difect radar wave and the indirect, reflected, wave off the sea.

BACK TO CAMBRIDGE AND ASTROPHYSICS :

After the war, Fred Hoyle, with a family to support, found a house to rent that he could just afford, its disadvantage being that it was twenty-five miles outside Cambridge. His friendship with Hermann Bondi and Thomas Gold grew, and they continued to collaborate, working in Bondi's rooms at Trinity College.

Since the discovery of the expansion of the Universe by Edwin Hubble, a time-scale for the Universe had been derivable as the inverse of the rate of the expansion (the Hubble constant) given by the recession velocity of galaxies, measured from the Doppler shift in their spectra toward the red, the shift of th spectrum lines of elements like ionized calcium. Hubble had shown that this redshift was proportional to the distances of galaxies as measured by their apparent luminosities.

From this, one could therefore derive an age for the Universe. The trouble was , this age as derived in the 1940s was less than the age of the Earth and the solarl system, which were known to be much older. Various theories were devised to deal with the problem, but the idea of a "steady-state Universe," in which the decreasing density due to the expansion of space was compensated by a steady creation of new matter, was the one that Bondi and Gold and, separately, Hoyle, put forward. This idea aroused bitter opposition and an immediate attempt to demolish it with observational arguments that were mostly shown to be wrong. However, the ages of stars composing massive galaxies, which were becoming known largely through work by Hoyle himself and Raymond Lyttleton (his friend and early collaborator in Cambridge), caused the simple steady-state theory of the Universe to fail. This time scale problem was addressed decades later, by Hoyle and colleagues, in a "Quasi-Steady-State Cosmoloyg" with successive stages of expansion and contraction. This was published in detail in 2000, shortly before Fred's death.

The major advances in the understanding of stellar structure and stellar evolution began when it was realized, largely through Fred's work, that the red giant stars had evolved from stars like, but more massive than, our Sun through the development of inhomeneity in their structure. A helium core, the residue of the main energy-producing nuclear reactions that convert hydrogen to helium, would form, surrounded by the original, mainly hydrogen, envelope. After his original work on this with Ray Lyttleton, Fred Hoyle, with Martin Schwarzschild at Princeton University, wrote a major paper on the physics of the formation of the red giant stars.

But earlier than this, Fred had been intrigued by recent data on the relative abundances of the chemical elements, as detailed analysis of the spectrum of the sun revealed an interesting abundance peak at the element iron, where the physics of nuclear structure showed that the protons and neutrons formed the most well-packed structure. This was Fred's entry into one of his major triumphs- the demonstration that the chemical elements are produced, not in some transcendent "origin of the Universe," but by the energy-producing reactions in stars; hydrogen to helium, helium to carbon, and on until iron in reached. Fred's original work on this was published in a forty-page paper in 1946.

Eleven years later, the work of Fred, William A. Fowler from Caltech, who was spending a sabbatical year in Cambridge, and my husband and myself, was published as an account of the production of the elements, from the lightest to he heaviest, in stars at various stages of their evolution, culminating in explosion as supernovae and dispersal of the products of nucleosynthesis into the diffuse matter

between the stars, raw material for the formation of successive generations of stars. A major step leading to this success had been Fred's prediction that there must be a resonance in the nuclear reaction involving carbon and oxygen, which would allow carbon to build up and not be scoured out by the subsequent reaction building oxygen. The experimental nuclear Physics group at Caltech told him there was no such energy level, that they had much experimental data demonstrating this. Fred, however, persisted; he calculated the level to be at about 7.65 MeV. He persuaded them to repeat the experimental work and, sure enough, the level was found, just where Fred had calculated!

Among his many other occupations, Fred Hoyle became interested in the idea that the famous stone circle in southwest England, Stonehenge, could be interpreted as an ancient circle built with an astronomical application , and he wrote a book on this subject.

RADIO ASTRONOMY IN CAMBRIDGE :

Sir Martin Ryle headed one of the two major establishments for radio astronomy, at Lord's Bridge just outside Cambridge (the other being Jodrell Bank, in Cheshire in the north of England). The concept of a "steady-state Universe" did not sit well with Sir Martin. With the Cambridge equipment and the group of researchers that he headed, he set out to prove it wrong. Taking counts of the number of discrete sources, whose nature at that time was ill understood, he derived a graph of number versus intensity that disagreed with what a "steady-state Universe" would display. The Cambridge counts, however, differed from what radio astronomers in Australia were finding in the Southern Hemisphere, which did not exclude a steady-state universe. The results of the Cambridge counts were subsequently modified, but Ryle never got over the ill feeling produced by this disagreement.

THE INSTITUTE OF THEORETICAL ASTRONOMY:

Fred's achievements in astrophysical research led to his election in 1957 to the Plumian Professorship, held earlier by Sir Arthur Eddington, and then by Sir Harold Jeffreys, the geophysicist. By then Fred had a distinguished record in research and in the education of students who themselves became distinguished astrophysicists. The radio sources in the sky had been identified with external galaxies or the remnants of stars that had exploded as supernovae, not stars like out Sun as originally believed by Ryle's group.

In addition, Fred had become known as an author of books such as the set of lectures he gave for the British Broadcasting Company, *The Nature of the Universe*, a political book, *Decade of Decision,* and numerous popular scientific texts, as well as science fiction stories that have stood the test of time and are still read with enjoyment.

But Fred had no space where he could gather a number of colleagues and students, and hold international conferences or summer schools. Early in the 1960s he started planning for such an institute in Cambridge, which should have the best available computing equipment-Fred was an early convert to electronic computing. It took hard work, and some disappointments, but, with crucial support from Sir John Cockcroft, master of Churchill College, and Lord Todd, professor of chemistry at Cambridge and chairman of the government's Advisory Committee on Scientific Policy, the Institute of Theoretical Astronomy came into being, on a piece of land next to the historic Cambridge Observatories building. A building, in whose design Fred's ideas played no small part, was completed on 1 August 1967. Expanded, and now named the Institute of Astronomy, it was the site of the first memorial symposium for Fred, held in April 2002.

THE ANGLO-AUSTRALIAN TELESCOPE :

After years of discussion of the need for a large, well-instrumented optical telescope in the Southern Hemisphere, the location for such a telescope was decided: it should be in Australia, on what had been found to be the best site, Siding Spring mountain in New South Wales.

A board of six people, three from Australia and three from the U.K., was set up to plan, design, choose contractors, and arrange for its management. Australia does not have the ideal climate or terrain for optical astronomy, as do the west coasts of the U.S. and Chile, but it has a strong scientific expertise and is the location of the very influential radio astronomy groups. That Fred was a member of the board and participated in all the key decisions, from design to future management, was crucial in achieving the AAT. The telescope was completed and dedicated by Prince Charles, the Prince of Wales, in October 1974, with Sir Fred Hoyle presiding at the dedication. It has produced world class science ever since.

DEPARTURE FROM CAMBRIDGE :

The relationship between Sir Fred Hoyle and the bureaucrats within Cambridge University was always a delicate balance, and there were those who resented the success of the Institute of Theoretical Astronomy. A succession of events, which this memoir is not the place to describe, took place in 1972. Fred resigned his professorship and departed with Barbara to the North Country, where perhaps his heart had always remained. The lovely house they had designed, across the Madingley Road from the Institute and the observatory, was sold, and they bought a house in Cumbria, a house designed by the previous owner for the excellent reproduction of recorded music.

Both Manchester University, home of the Jodrell Bank radio telescopes, and Cardiff University in Wales (where Chandra Wickramasinghe, a former student of Fred's, was professor and head of a major research group investigating the properties of the diffuse matter between the stars) offered positions, but Fred, who did all his creative writing sitting in a comfortable chair at home with a writing pad on his knee, declined to accept either. He lived in the U.K. Lake District until the harsh winters became too much, and he and Barbara moved to Bournemouth on the south coast of England. This had the advantage of proximity to his son, Geoffrey, with whom Fred had written and continued to write many science fiction stories.

This move did not end Fred's research. The book describing a "Quasi-Steady-State Cosmology," which I mentioned earlier, was written, the communication with his coauthors in California and India being done mostly by fax. His interest in music was maintained, and he wrote the lyrics for several pieces composed by the American composer Leo Smit. He wrote science fiction, much of it jointly with his son, Geoffrey. He wrote a science fiction serial for the BBC entitled *A for Andromeda,* which was a great success.

Fred died on 20 August 2001. He is survived by Barbara, his wife of more than sixty years, his daughter, Dr. Elizabeth Butler, his son, Geoffrey, and grandchildren on both his son's and his daughter's side. His friends cherish his memory.

Elected 1980

E. Margaret Burbidge
University Professor Emeritus
Research Physicist
Center for Astrophysics and
Space Sciences
University of California, San Diego

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Sir Fred Hoyle

[Born : 24 June 1915 in Bingley, Yorkshire, England

Died : 20 Aug 2001 in Bournemouth, England]

Fred Hoyle's parents were Ben Hoyle and Mabel Pickard. Mabel's father had died when she was a small child. As a young girl she had worked in a mill in Bingley and had saved up enough money to study music at the Royal Academy of Music in London. After training there she decided not to perform but she taught music in schools before marrying Ben. Like Mabel. Ben had worked in a mill. He had been forced to leave school at the age of eleven since his family were too poor to support his education any longer.

Fred's parents bought 4 Milnerfield Villas on the outskirts of the village of Gilstead in south Yorkshire in 1910 and they were living there when World War I broke out in 1914. Their first child was Fred who was born at 4 Milnerfield Villas just before his father was conscripted into the British army, choosing to join the Machine Gun Corps. Quite why he chose this is unclear for the chances of survival were extremely slim and one might have thought that, with a wife and young child, he would have tried to maximize his chances. Obviously he did not think in this way, and against all the odds he survived the war. It was an extremely difficult time for Fred's mother who had to bring up her young child in difficult circumstances, living in continual fear that she would receive a letter telling her that her husband had been killed. Mabel earned a little money by playing the piano for the silent films in Bingley cinema. She also provided Fred with his early education, in particular teaching him numbers.

After World War I ended Ben returned to civilian life and he set up a cloth business (particularly dealing in wool) in Bradford, the nearest large town. At first the business did well and in 1920 it was decided to send Fred to a small private school. However there was a sharp downturn in business in general in 1921 and by the time that Fred started school his father's cloth business was suffering badly. The start of Fred's school education marked the beginning of a difficult time [2]:-

> ***Between the ages of five and nine, I was perpetually at war with the educational system. My father always deferred to my mother's judgement in the several crises of my early educational career, because she had been a school teacher herself… events would suggest that my mother was unreasonably tolerant of my obduracy. But, precisely because she had been a teacher herself, my mother could see that I made the best steps when I was left alone.***

Fred only attended the private school for a few weeks in July 1921 before his father decided to temporarily give up his failing cloth business and move to Rayleigh in Essex. There Fred entered a school near Thundersley and immediately made friends with a classmate. The pair worked out a way to play truant but before they had much chance to try their scheme out Fred's family returned to Gilstead in November 1921 on hearing that there were problems with the people to whom hey had let their house. Back home, Fred was returned to his first school in January 1922:-

> ***I returned to the same private school as before, but I returned no longer an innocent child prepared to have irrelevant knowledge poured into my head by the old beldame who ran the place.***

In March Fred put his truancy scheme into practice and while his parents believed he was at school, the school believed that he was ill at home. After a couple of months his parents found out what was going on, but he was allowed to choose a new school instead of returning. He decided to attend Morning Road School in Bingley but there he performed rather poorly in tests that were carried out. This was hardly surprising since he had avoided school most of the time up till then, and soon he was avoiding school again partly through genuine illness and partly through pretending to be ill during the winter of 1923-24.

Despite his attempts to avoid formal education Hoyle did show interest in educating himself. He read a chemistry book which belonged to his father and found an interest in the subject which would last a lifetime. However problems at Morning Road School prompted another move and he began to attend Eldwick school from September 1924. After Hoyle narrowly missed out on a scholarship for grammar school, an appeal was entered and he scraped through beginning his studies at Bingley Grammar School in September 1926. His war with the education system had ended, and although there were still many educational problems ahead, he now approached education with a much more positive attitude.

In 1927 Bingley town library acquired a copy of Eddington's Stars and Atoms and Hoyle read it avidly. By the end of his first year at the Grammar School, he had progressed from his entry position of 16th in the class to top the class. His interest in chemistry continued and as he neared the end of his school career he decided to go to Leeds University to study chemistry there. Taking the scholarship examinations in September 1932 he narrowly missed out. Unable to study at university without a scholarship, he returned to Bingley Grammar School but instead of working steadily through the year with the aim of gaining a scholarship to Leeds at the second attempt, Hoyle decided to aim at a Cambridge University Scholarship. It ws an ambitious scheme but one which he felt would at least give him practice at taking such examinations.

Bingley Grammar School did not really have the teaching resources to bring Hoyle rapidly up to Cambridge Scholarship standard, but the mathematics teacher did his very best and gave him lessons in his own home. Hoyle sat the scholarship examinations in Emmanuel College Cambridge in December 1932:-

> ***If a miracle happened and I won something in Cambridge, well and good. I would be glad to accept it, but my real aim… was to prove to myself that the efforts of the past three months had really improved my standards.***

Hoyle's performance was good in physics and chemistry but, as he expected, his preparation for mathematics had been weak and the mathematics paper dragged him down. He missed the scholarship standard but decided to take the scholarship examinations at Pembroke College, Cambridge in March 1933. This time his performance was better and he did make the scholarship standards, but the College did not have scholarships for everyone who

made the standard, and again Hoyle missed out. However, he could now get into Cambridge by winning a scholarship in the Yorkshire scholarship competition and he was successful in this in the summer of 1933, with now mathematics as his best subject.

In the autumn of 1933 Hoyle entered Emmanuel College, Cambridge, intending to read for a degree in science. His tutor was a mathematician, P W Wood, who told him at their first meeting that his mathematics was not good enough to read for a degree in science so he advised that Hoyle take Part I of the Mathematical Tripos which would put him in a good position to study science after that with a better grounding in mathematics. So Hoyle embarked on the one year mathematics course, entering at the bottom level of the slow stream. His aim was to get himself into the middle of the slow stream by the time he took Part I of the Mathematical Tripos and indeed he achieved better than this for he was in the top quarter of this slow stream by the end of year one.

Having achieved his aim in mathematics, it would have been natural for Hoyle to move into the science course as he had intended. However, he was always one to rise to a challenge and having progressed so well it was natural for him to wonder how much higher he could climb in mathematics. There was another argument which told him to carry on with mathematics which was that the great Cambridge scientists like Newton, Maxwell, Kelvin, Eddington and Dirac had all been mathematicians. He decided to carry on and entered his second year of study of mathematics at the bottom of the fast stream. Again he progressed well and ended the year well into the top half of the class.

Hoyle was taught by some outstanding people while he was an undergraduate at Cambridge. For example Born taught him quantum mechanics, Eddington taught him general relative , and he was also taught by Dirac. He was placed in the top ten when he took the Mathematical Tripos in 1936 and was awarded the Mayhew Prize as the best student in applied mathematics. Continuing to study at Cambridge, his research was supervised by Rudolf Peierls and his career went from strength to strengh with the award of the top Smith's Prize in 1938 and then, with Peierls and R H Fowler as referees, he was awarded a prestigious Goldsmith's Exhibition. By this time he was being supervised by Maurice Pryce who took over when Peierls went to the chair of Applied Mathematics at Birmingham. In 1939 Hoyle published a major paper on Quantum electrodynamics in the Proceedings of the Cambridge Philosophical Society. Although Hoyle had completed the work for a Ph.D. by then he was persuaded by Pryce not to submit (the Ph.D. was new to Cambridge and Pryce did nto approve of it).

Although his research was in applied mathematics, it was through the problem of accretion of gas by a large gravitating body which Ray Lyttleton discussed with him that Hoyle's interests turned towards mathematical problems in astronomy. With everything going his way, with election to a Fellowship at St John's in May 1939 for work on beta decay and receiving a highly prestigious award from the Commission for the Exhibition of 1851, his career was suddenly put on hold with the outbreak of World War II [2]:-

> ***War would change everything. It would destroy my comparative affluence, it would swallow my best creative period, just as I was finding my feet in research.***

Shortly after the outbreak of war Hoyle married Barbara Clark on 28 December 1939. They had one son Geoffrey (with whom Hoyle would have several joint publications) and one daughter Elizabeth. During the war Hoyle worked for the Admiralty on radar, doing most of this work in Nutbourne. He had little time for research in astronomy but continued collaboration with Lyttleton when it proved possible (one occasion being when he had leave in 1942 for the birth of his first child Geoffrey). During his time with the Admiralty Hoyle worked with Hermann Bondi and Thomas Gold and he discussed astronomy with them in spare moments. These three would later

propose "steady-state cosmology" for which Hoyle is probably best known.

In 1944 he visited the USA because of his work on radar and while there he worked out what was going on with the atomic bomb project. This led him to think of nuclear reactions, and out of this came one of his most important ideas about how the elements were created. He returned to Cambridge at the end of the war as a Junior Lecturer in Mathematics. His teaching duties were to give a geometry course and a statistical mechanics course in 1945-46. In 1945 he published *On the integration of the equations determining the structure of a star* which discussed the most advantageous way of integrating the equations of stellar equilibrium. In the spring of 1946 he wrote his important paper which developed from the ideas he had about the cration of the elements *The Synthesis of the Elements from Hydrogen* which appeared in the *Monthly Notices of the Royal Astronomical Society.*

After three years as a Junior Lecturer in Mathematics, Hoyle was promoted to Lecturer in Mathematics at Cambridge and given tenure. He stopped teaching geometry, teaching instead courses on Electricity and Magnetism, and on Thermodynamics. His range of publications broadened with works on many different topics and at many different levels. In 1948 he published two papers on steady-state cosmology. His first move into explaining science to a general audience came in 1950. He broadcast five astronomy lectures on the Third Programme (now called Radio 3). These were extremely popular and were often repeated, with versions being broadcast in the United Sttates and a book *Nature of the Universe* being published based on the lectures. It was in the last of these five lectures that Hoyle coined the phrase "Big Bang" for the creation of the universe. Although now accepted by most scientists, the term was actually meant to be a scornful description of the creation theory which Hoyle did not accept.

Inn 1957 Hoyle published his first science fiction novel *The Black Cloud* which achieved much praise and has since become a classic (about a dozen of his 40 books have been on science fiction) [1]:-

> ***… he wrote [science fiction] scuccessfully for more than three decaes, winning a devoted following . His most famous novel was 'October The First Is Too Late'. In which Britain and Hawaii remain in 1966, the Americas are switched back to the 15th century and the Soviet Union exists in a future time when the surface of the Earth is a plate of glass.***

Hoyle also wrote the television serial *'A for Andromeda'* and the children's play *'Rockets in Ursa Major'*. When this was performed in 1962 at the Mermaid Theatre, one critic wrote: "Seldom can scientific mumbo-jumbo have sounded so convincing." This writing, Hoyle believed, complemented his serious work, in the middle of which he would stop to indulge in what he called "whimsical fantasies." He was convinced that really important discoveries were most likely to come from an exercise of creative imagination.

He became Plumian Professor of Astrophysics and Natural Philosophy on 1 October 1958 after Harold Jeffreys retired, a position which he held until he resigned in 1972. During his tenure of the chair continued to published many important works such as his collaborative work with William Fowler, *Nuclear cosmochronology* published in 1960 in the Annals of Physics which described how the observed ratios of the abundance of different isotopes of uranium and thorium can be used to determine a cosmical time-scale . In 1966 Hoyle founded the renowned Institute of Theoretical Astronomy at Cambridge and was its Director until 1972.

The events leading up to Hoyle's resignation from Cambridge in 1972 are recounted in [2]. He explained his reasons in a letter to Lovell (see[5]) :-

> ***I do not see any sense in continuing to skirmish on a battlefield where I can never hope to win. The Cambridge system is effectively designed to prevent one ever establishing a directed policy-key decisions***

can be upset by ill-informed and politically motivated committees. To be effective in this system one must for ever be watching one's colleagues, almost like a Robespierre spy system. If one does so, then of course little time is left for any real science.

Following this he made his home in the Lake District but he continued to come up with interesting, and often unconventional, theories such as those concerning Stonehenge, panspermia (that the origin of life on Earth must have involved cells which arrived from space), Darwinism, palaeontology, and viruses from space. I [EFR] was lucky enough to hear Hoyle speak about his theory that Stonehenge was built as an eclipse predictor. It was an inspiring talk which, like so much of Hoyle's work, really made one think about things in a new light. Hoyle continued to publish up to the end of his life with *Mathematics of evolution* appearing in 1999 and *A different Approach to Cosmology: From a Static Universe through the Big Bang towards Reality* (written jointly with G Burbidge and Narlikar) being published in 2000.

Hoyle received many honours. He was knighted in 1972. He was elected to many academies and learned societies including the Royal Society of London (1957), the National Academy of Sciences of the United States (1969), the American Philosophical Society (1980), the American Academy of Arts and Science (1964), and the Royal Irish Academy (1977). He received many honours including: the United Nations Kalinga Prize in 1968, the Gold Medal of the Royal Astronomical Society in 1968, the Bruce Medal from the Astronomical Society of the Pacific in 1970, the Royal Medal of the Royal Society in 1974, the Dag Hammarskjöld Gold Medal, the Karl Schwartzchild Medal, the Balzan Prize in 1994, and the Crafoord Prize awarded by the Royal Swedish Academy of Sciences in 1997. Typical of the citations he received for such awards was that of the Royal Medal which states that his:-

... enormous output of ideas are immediately recognized as challenging to astronomers generally…his popularization of astronomical science can be warmly commended for the descriptive style used and the feeling of enthusiasm about his subject which they succeed in conveying.

Wickramasinghe writes in [7]:-

…Hoyle sought to answer some fo the biggest questions in science: How did the Universe originate? How did life begin? What are the eventual fates of planets, stars and galaxies? More often than not he discovered answers to such questions in the most unsuspected places. For instance he discovered that the secret of how stars evolve lay in a certain property of the carbon nucleus, a property (a resonance) that was not discovered until Fred himself had pointed to its absolute necessity.

Fred believed that, as a general rule, solutions to major unsolved problems had to be sought by exploring radical hypotheses, whilst at the same time not deviating form well-attested scientific tools and methods….

Fred Hoyle had no respect for the boundaries between scientific disciplines which were artificial social constructs that often stood in the way of a proper comprehension of the cosmos. The Universe does not respect the differences between physics, chemistry and biology, he would say, and his career in astronomy progressively embraced all these disciplines.

Martin Rees has written this tribute:-

Hoyle's enduring insights into stars, nucleosynthesis, and the large-scale universe rank among the greatest achievements of 20th – century astrophysics. Moreover, his theories were unfailingly stimulating, even when they proved transient. He will be remembered with fond gratitude not only by colleagues and students, but by a much wider community who knew him through his talks and writings.

Article by : J J O'Connor and E F Robertson

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HOYLE, SIR FRED

Biographical Profile

British Mathematician and Astronomer

[Born June 24, 1915, Bingley, Yorkshire, England
Died : 20 Aug 2001 in Bournemouth, England]

In the decades following the postulation of the theory of a steady-state universe, Hoyle was its outstanding spokesperson and staunchest defender. He modified Albert Einstein's equations of general relativity in such a way as to lead to a mathematical form of the steady-state theory, which provides for a homogeneous, isotropic model of the universe with the continuous creation of matter:

In 1948 the British astronomers Hermann Bondi and Thomas Gold presented a theory of the steady-state, or continuous- creation, universe. They began with the assumption that if the universe is homogeneous in space, it must also be homogeneous in time; that is, the universe must have always looked in the past, and will always look in the future, essentially the same as it looks now. Since the universe is steadily expanding, they maintained that elementary matter is continuously created to fill the void of space. From these randomly produced particles, agglomerations of matter the size of galaxies and of clusters of galaxies eventually are formed. When the continuing expansion of the universe removes some galaxies from the range of vision, other newly formed systems take their place to keep the universe in a steady state. However, the Bondi-Gold model of the universe was not based on a generalized field theory, but on an intuitive physical principle.

About 6 months previously at Cambridge University, Hoyle had set out to develop a mathematical basis within the logical framework of the theory of relativity for steady-state theory. Einstein had generalized the ordinary laws of motion in three-dimensional space to describe the properties and the non-Euclidean geometry of the four-dimensional space-time field. These generalizations took the form of four equations, one for the law of conservation of energy and three for the conservation of momentum. Hoyle first defined energy and momentum, which are not defined by the general theory of relativity, in such a way as to account for a generalized analog of fluid stresses, and then framed a law of origin of matter so as to be able to introduce it into the four conservation equations. The equations then implied

a relation between the expansion of the the universe and the origin of matter within it: The rate of expansion and the rate of origin of matter would tend to regulate each other. This interaction between the expansion and the creation of matter maintains a steady state in which the mean density of matter in the universe remains constant.

The model univese employed in the theory is a modified version of the original de Sitter universe, removing Willem de Sitter's restriction that the universe must be empty of matter. Hoyle explained the concept of continuous creation of new matter in space, which appears to be a violation of the law of conservation of energy, as being possible because the universe-in de Sitter's model-is an open system. According to Einstein's general theory, in an open, infinitely expanding universe local concentrations of energy are related to the energy of expansion of the whole universe. It is this expansion energy that can lead to the continuous creation of local matter.

In the light of empirical observations during the 1950s and 1960s that appeared to favor an evolutionary, or "big-bang," rather than a steady-state universe, Hoyle was forced to modify his conclusions several times. Although it is theoretically possible to subject the steady-state theory to empirical testing, the limitations of the precision of the instruments that must be used have negated attempts.

Hoyle also made a number of significant contributions to astrophysics. In collaboration with E.M.Burbidge, G.R. Burbidge, and W.A. Fowler, he proposed a comprehensive theory of all of the elements in stars, starting from pure hydrogen. Hoyle described a scheme of nuclear ractions within stellar interiors that goes beyond the hydrogen-helium mechanism elaborated by Hans Bethe. He also did considerable work on stellar origins and, together with Fowler, predicted the existence of very massive objects 6 months or more before the discovery of quasistellars.

Hoyle attended Cambridge University, receiving his M.A. in 1939 from St. John's College; his doctorates in science were granted by the Universities of Norwich (1967) and Leeds (1969). In 1939 he was elected a fellow of St. Johns College. During World War II he worked on radar development for the British Admiralty. Hoyle returned to Camnbridge in 1945 as lecturer in mathematics. He became Plumian Professor of Astronomy and Experimental Philosophy in 1958 and director of the Institute of Theoretical Astronomy in 1966. He was a staff member of the Mount Wilson and Palomar Observatories from 1956 to 1962, dividing his time between California and Cambridge. Hoyle became professor of astronomy at the Royal Institution in London in 1969; was made Andrew D. White Professor-at-large at Cornell University in 1972; and held honorary positions at various academic institutions. He was elected to the Royal Society of London in 1957. Hoyle was made an honorable member of the American Academy of Arts and Sciences in 1964 and a foreign associate of the National Academy of Sciences in 1969. Among his honors are the Gold Medal of the Royal Astronomical Society (1968), the Bruce Medal of the Astronomical Society of the Pacific (1970), and the Royal Medal of the Royal Society (1974); he was knighted in 1972.

Among Hoyle's works are Some Recent Researches in Solar Physics (1949), The Nature of the Nuniverse (1950; 2d ed. 1960), Frontiers of Astronomy (1955), Of Men and Galaxies (1964), Galaxies, Nuclei, and Quasars (1965), Man in the Universe (1966), The Relatin of Physics and Cosmology (1973), Astronomy and Cosmology (1975), Energy or Extinction (1977), and Life Cloud (in press).

For backgroud information see COSMOGONY; COSMOLOGY; ELEMENTS AND NUCLIDES, ORIGIN OF in the McGraw Hill Encyclopedia of Science and Technology.

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The Bruce Medalists : Fred Hoyle

Fred Hoyle

Born : 24 June 1915 **1970 Bruce Medalist** **Died :20 August 2001**

Fred Hoyle was born in Yorkshire in northern England and educated in mathematics and theoretical physics at the **University of Cambridge,** where he worked under Rudolph Peierls and Paul A.M. Dirac. In the late 1930s he worked with Ray Littleton on stellar evolution and the accretion of interstellar matter onto stars. After wartime work on the development of radar countermeasures he returned to Cambridge, where he remained from 1945 to 1973, with many long-term visits to the **California Institute of Technology** and other American institutions. He founded Cambridge's **Institute of Theoretical Astronomy** and served as its first director. As Plumian Professor of Astronomy at Cambridge he was a leader in British science and especiallyin the founding of the Anglo-Australian Telescope. With **Martin Schwarzschild** he developed the theory of the evolution of red giant stars. His early work on stellar evolution and nuclear physics led to his famous collaboration with **Margaret Burbidge, Geoffrey Burbidge** and **William Fowler** on the synthesis of the elements beyond helium in stars.

In 1948 Hoyle, Hermann Bondi, and Thomas Gold developed the steady state cosmological models. Hoyle provided a mathematical theory of the model which was an extension of the general theory of relativity and featured continuous creation of matter. The leading spokesman for the new theory, he coined the term 'big bang' for the competing model during a radio lecture. He worked on numerous other problems in theoretical astrophysics and cosmology--- from the origin of the solar system to the nature of quasars. In 2000, long after nearly all cosmologists had accepted the evidence for an evolving universe, Hoyle, Geoffrey Burbidge, and N.V. Narlikar supported a (quasi) steady state universe in a book. Hoyle was also the proponent of the equally unpopular idea that **life came to earth from elsewhere**. This theory resulted from his extensive collaboration with **Chandra Wickramasinghe** on the infrared spectra of interstellar grains. The author or coauthor of much science fiction, a play, and mored than twenty nonfiction books, Hoyle was a leading popularizer of science.

Presentation of Bruce Medal :

- Abell, George O., *PASP **82,** 567 (1970).*

Other Awards :

- American Astronomical Society, Henry Norris Russell Lectureship, 1971.
- Association pour le Devéloppement International de l' Observatoire de Nice, ADION medal, 1986
- Astronomische Gesellschaft, Karl Schwarzschild Medal, 1992.
- International Balzan Foundation, Balzan Prize, 1994.
- National Radio Astronomy Observatory, Jansky Prize, 1969.
- Royal Astronomical Society, Gold medal, 1968, presented by D.H. Sadler, OJRAS **9,** 271-73 (1968).
- Royal Society, Royal Medal, 1974.
- Royal Swedish Academy of Sciences, Crafoord Prize, 1997.
- **UNESCO, Kalinga Prize, 1967.**

Some offices held :

- Royal Astronomical Society, President, 1971-73.

Biographical Materials :

- Anonymous, FredHoyle.com
- *Burbidge, Geoffrey,* Biographical Memoirs of the Royal Society **49,** 215 (2003)
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Fred Hoyle
A Life Well Lived

Sir Fred Hoyle, FRS (June 24, 1915 – August 20, 2001), was an astrophysicist most famous for being a proponent of the steady state universe, a theory that says the universe is infinitely large and infinitely old. Hoyle also disparagingly coined the term "big bang" to describe the competing theory that the observable universe originated in a great "explosion" of matter and energy some 15 billion years ago. He also theorized that life may have originated in space (particularly in molecular clouds and on comets rich in organic molecules) rather than on planets, a theory called panspermia.

Hoyle was born in Yorkshire, England, and was deeply interested in astronomy as a boy. He studied mathematics at Cambridge University, where he was elected a fellow of St. John's College in 1939 with his dissertation on quantum electrodynamics. During World War II he worked on the development of RADAR for the British Navy, but returned to a professorship at Cambridge after the war. He was elected Plumian Professor at Cambridge in 1958, and founded the Institute for Theoretical Astronomy in 1966.

Hoyle is most positively remembered for his work on nucleosynthesis, particularly for his work energy generation and nucleosynthesis in stars with Margaret and Geoffrey Burbidge and Willy Fowler, published in Reviews of Modern Physics in 1957 (volume 29, number 4, page 547). This article (more of a book, at 108 pages) was and is one of the seminal works on nucleosynthesis in astrophysics. In fact, it is the result of Hoyle's work that we now understand that all elements more complex than helium seen in the universe were generated within stars, and dispersed via supernova explosions and stellar mass loss. (That includes the carbon, oxygen and other stuff that makes up you.) Hoyle also contributed to the fields of stellar structure, and star and planetary formation over the years.

However, much of Hoyle's fame (or notoriety) comes from his investigations into "nonstandard" explanations for physical phenomena in the universe. In 1948, Hoyle, along with Hermann Bondi and Thomas Gold originated (in astrophysics at least) the idea of an eternal universe, dubbed steady-state cosmology (two articles in Monthly Notices of the Royal Astronomical Society volume 108, pages 252 and 372).In this theory, they suggested that matter is being spontaneously created from nothing (perhaps from vacuum energy?), in order to explain the observed Hubble expansion of the universe. The idea of continuous creation wasn't new, having been discussed by James Jeans twenty years prior to this. However, Hoyle, Bondi, and Gold were the first to apply it to relativistic cosmology. This theory competed with the big bang theory, which states that the universe originated at a time in the finite past, expanding over time from an initial hot, dense singularity.

The steady-state theory fell into disfavor after the discovery of the cosmic microwave background in 1965, which is most easily explained by the big bang theory. To the end of his life, Hoyle tried to improve his steady state theory to explain observations, but was never successful. It is noteworthy that Hoyle collaborated with the astronomer Halton Arp in the 1980's, the latter of whom believed that quasars are in fact ejected from the cores of galaxies, and that their "redshifts" are intrinsic properties of this "young matter" rather than being caused by high recession velocities (despite, I should add, volumes of thoroughly investigated

evidence to the contrary). Apparentloy Hoyle felt Arp's rejection of cosmological redshifts and the "creation" aspect of his quasar theory supported steady state.

Hoyle was truly notorious for his theories on evolutionary biology, particularly those he developed with mathematician Chandra Wickramasinghe of University College, Cardiff, Wales. One theory they advanced was the idea that life originated in space, particularly in places like comets and molecular clouds where organic molecules are abundant. If these organisms reach hospitable climates (like the young Earth, for example), they can then develop and diversify, resulting in all the life we see today. This in itself isn't too implausible, but they later expanded this theory to say that not only did life originate in space, but that evolution is not caused by random mutations and adaptation to local conditions, but by mutagenic organisms from space. (The Daily Telegraph obituary mentions a 1990 article by Hoyle and Wickramasinghe stating that eruptions from sunspots push some of these interstellar microorganisms into Earth's atmosphere where they cause influenza epidemics, AIDS, and other diseases.) Hoyle always maintained that he believed Darwinian evolution was wrong, and was often criticized quite heavily for it. However, that criticism was often earned, as for example when Hoyle and Wickramasinghe wrote the book Archaeopteryx, the Primordial Bird:A Case of Fossil Forgery, saying that the best Archaeopteryx fossil was faked. The book was brutally attacked by paleontologists and biologists, not because it went against the common understanding of evolution, but because its main premise was demonstrably false (the fossil is quite real). However, it should be noted that the work of Hoyle and Wickramasinghe was not without merit; they conducted very extensive and valuable work on the properties of dust grains in the interstellar medium throughout the 1980's as part of their research on panspermia.

Hoyle left Cambridge in 1973 over a funding dispute, and served as a visiting professor at several universities around the world, notably at CalTech, Cardiff, and at Rice University where he continued his work on nucleosynthesis in the mid-1970's with Donald Clayton. Hoyle retired to Bournemouth in the early 1990's, though he continued to give invited lectures world wide, and write articles on his various theories. He was involved in scientific research until his death. But besides his scientific work, he was also an author of science fiction, and wrote several well-received novels, including The Black Cloud. He also wrote A is for Andromeda, about aliens who beam instructions for building a doomsday machine to Earth. Both works apparently featured very accurate descriptions of physics and science, unlike much of the science fiction of the 1950's and 1960's. (I haven't read any of them, so I will leave a review of those to another noder.)

Hoyle was elected to the Royal Society in 1957, and elected the Plumian Professor of Astronomy at Cambridge in 1958; he was knighted in 1972. He received many other awards in his life, including the Gold medal of the Royal Astronomical Society (1968), the Henry Norris Russell Prize of the American Astronomical Society (1971), the Royal Medal of the Royal Society (1974), and the Bruce Medal of the Astronomical Society of the Pacific (2000) for lifetime achievement in astronomy. Minor Planet 8077 was named after Hoyle, as is the home of the Institute for Theoretical Astronomy at Cambridge which he created.

Hoyle had many controversial ideas during his lifetime, and some (probably not all) of the criticism of him was probably justified. He was certainly an independent thinker, and was – admirably – not afraid to discuss his ideas. It I had to criticize him, I'd probably say he probably held onto failed theories too long in the face of contradictory evidence, particularly his views on cosmology. But despite his controversial work, he did make very important contributions in the field of astrophysics, and should certainly be remembered (and honored) for them.

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Fred Hoyle : Scientist of Multifaceted Talents

A Tribute

J.V Narlikar

Sir Fred Hoyle, the most original and versatile astrophysicist of our times passed away on 20 Auguest 2001. He is survived by his wife Lady Barbara Hoyle, son Geoffrey and daughter Elizabeth. I had the privilege of being his student and later a coworker. The following impressions do only partial justice to a multifaceted personality.

I recall an event in 1964-1965. A play was staged in the newly built Mermaid Theatre in London, on the south bank of the river Thames. London is well-known for plays, both established ones as well as new experimental plays. In Shakespeare's times, there had been a theatre of the same name on the south bank of the river. The new Mermaid Theatre had been rebuilt on the same site. That evening, the theatre was full to capacity, but not for a Shakespearean play.

And, there was another difference. The average age of the majority of the audience was 8-14 years. Because, the play was based on science fiction and was written specially for children. To suit them, these shows had been arranged during the Easter vacation. The unusual thing was that it was not written by a professional playwright from the literary world, but by a scientist, famous for his research in astronomy. The name of the play was 'Rockets in Ursa Major', and the author was Fred Hoyle.

In the early part of the twentieth century, the distinuguished scientish James Jeans from Cambridge contributed significantly towards making astronomy popular amongst common people. The lecture halls used to be 'packed' during his lectures and his books were internationally read and acclaimed. Hoyle, also from Cambridge, was a worthy successor of Jeans.

Fred Hoyle was born on 24 June 1915, in a little village called Bingley in Yorkshire. (Fred is not a shortened version of Frederick; in Yorkshire it is a complete name by itself.) Fred's father used to trade in cloth materials and his mother was an expert in music, especially in playing the piano. Fred developed interest in the piano as well as in mathematics, when he was small. His power of analytical reasoning was demonstrated at the age of three, when he had worked out the way to read the clock and tell the time, all by himself.

At a young age, Fred developed interest in astronomy. The Hoyles, father and son, would walk eight miles to the house of a friend who had a telescope, and would return early in the morning after a night of sky-watching. Astronomy encouraged his inquisitive and highly original mind. He also was something of a rebel and would not accept the conventional wisdom, unless his mind was satisfied as to its correctness.

In his first primary school, a teacher once taught in the class that a certain type of flower has five petals. The next day, Fred produced a flower of the same kind with six petals and asked the teacher to justify her statement. The teacher, embarrassed and angered by this counter example, smote the boy's ear. Shocked by this unjustified response, Fed left school at once and came back home. He told his mother that he would never go to the school where such injustice prevailed. His mother supported his stand and argued his case with the school authorities, who finally gave her permission to change the boy's school. Later in his life, Hoyle

had to face many such incidents, whenever he challenged the set attitudes of the establishment.

Considered a bright student in his school, Fred entered the University of Cambridge with two scholariships, to do the mathematical tripos. He distinguished himself with a Mayhew Prize in the Part III of the tripos and a Smith's prize as a research student. His early work was more in atomic and particle physics rather than astrophysics; and he was elected to fellowship of St John's College for his essay on quantum electrodynamics.

When the second World War began, like many other scientists, Hoyle, too worked on wartime projects and helped develop research on the radar system. After the war was over, Hoyle came back to Cambridge and started work on his favourite subject – astronomy. This was a new era in his life, and it was Raymond Lyttleton who got him interested in problems of stellar structure. While Lyttleton was more in the classical mould of dynamics and worked with an overall mathematical approach, Hoyle brought more of physics into their collaboration.

The work on stellar structure naturally led him to the next step of stellar evolution. The problem facing astrophysicists in the early 1950s was how to proceed beyond the fusion of hydrogen to helium . An exothermic reaction was needed, if a star like the sun were to keep shining beyond this stage. Moreover, to Hoyle, who had a grand vision of making most, if not all chemical elements in stars, the problem posed by instability of nuclei of atomic masses 5 and 8 seemed a crucial one to solve. How otherwise can one climb the nuclear ladder? Ed Salpeter had suggested the triple-alpha process, in which three helium nuclei get together to form a carbon nucleus. But the problem was that a three-body collision seemed too rare an event to generate enough carbon or provide enough energy for the star to contiune shining. This was where Fred used his intuitive brilliance to propose that the three-body reaction is a resonant reaction, which proceeds fast and so compensates for the low probability of collision. He calculated the energy level of the resulting carbon nucleus so formed and found that it was an excited level. He therefore urged the nuclear physicists to look for such an excited level. Ward Whaling and Willy Fowler at Caltech after initial skepticism, performed the necessary experiments and found that Hoyle's prediction was correct.

This tour de force of Hoyle was motivated by anthropic consideration too! He had argued that unless such an excited level existed, there would not be enough carbon formed and so our own existence (with carbon as an essential ingredient) would have to be denied.

This success essentially began the new programme of nuclear astrophysics, with Fowler collaborating with Hoyle in problems of stellar evolution and nucleosynthesis. Later, they were joined by the husband-wife team of Geoffrey and Margaret Burbidge in a mammoth exercise of demonstrating how most nuclei are indeed formed in stellar processes, from a sun-like beginning, and in the extreme case, a supernova-type explosive end. This work published in 1957 in the Reviews of Modern Physics has stood the test of time and is referred to after its four authors as the B^2FH theory.

Hoyle's researches have given new directions to many branches of astrophysics. The origin of solar system, the evolution of stars, the origin of cosmic rays, the mystery of dust in the interstellar space, the phenomenon of accretion on stars, the formation of the Milky Way, radio sources, pulsars, quasars and , of course, his favourity branch- cosmology… In today's era of narrow specialization, it is extremely rare to find a scientist with such a variety of research interests and with such a seminal record of contributions with high impact factor.

In 1948, together with Hermann Bondi and Tommy Gold, he proposed the steady state theory of thre universe. At that time, the established opinion was that the universe was created in a huge explosion, the so-called 'big bang'; and most of the scientists opposed this new theory. But Hoyle was firm in his

conviction about the untenability of the big bang cosmology and was always ready to argue with other scientists. In fact, the name 'big bang' was given by Hoyle to this model in the course of a programme of popular radio talks on the BBC, more as a cynical description of that mythical primeval event that as a serious epithet.

If a theory is to be scientifically disproved, then one should point out a logical contradiction in it or demonstrate that some prediction of the theory is disproved by observations. During 1950-disproved by observers claimed to have results relating to discrete source like galaxies, radio sources, etc. that were contradictory to the steady state theory; but later, after close scrutiny, all of them turned out to be unforned. The observation that really fatally affected the theory, however, was the discovery in 1965 of the cosmic microwave background.

There was a time, perhaps for 4-5 years after this event, when Hoyle wavered in his opposition to the big bang. His work with Bob Wagoner and Willy Fowler in 1967 demonstrated in a most comprehensive way, how light elements could be produced just after the big bang. This is still cited as the corner-stone of modern big bang nucleosynthesis. Most astronomers were surprised when Hoyle's name did not appear alongside Fowler's in the 1983 list of Nobel awards in physics. He did, however, receive two prestigious awards, the Crafoord Prize and the Balzan Prize.

However, as time passed he felt that the big bang paradigm was sinking more and more into speculations of the very early universe, with nothing beyond the microwave background and light element abundances to show for it as direct evidence. He therefore returned to his initial skepticism and by 1993 had revived the old steady state theory with Geoffrey Burbidge and Jayant Narlikar, in a modified form. Called the Quasisteady state cosmology, this alternative was able to account for the elemental;abundances and the microwave background, besides explaining observations of discrete source counts. His last book was the magnum opus called A different Approach to Cosmolgoy, written with his above two coworkers. Despite propagating heretical views, the book is doing well in terms of readership.

Hoyle believed that a scientist should be sensitive to the issues affecting society and he himself did not hesitate to express his opinions publicly. In the 1970s he wrote a book arguing that nuclear power alone can solve the energy crisis of the world. He had published a scholarly book which seeks to relate the old relics at Stonehenge in England to practices related to astronomy in the ancient civilization. He gave well-argued lectures on the dangers of the future growth of population.

In 1957, Fred Hoyle published his first science-fiction novel, called *The Black Cloud*. This book was a great success and many readers felt that in Hoyle they had a reincarnation of H.G. Wells! But the difference here was that an internationally renowned sciengtist had attempted writing science fiction. The black cloud in the novel is formed of thinly-packed molecules with a brain which could think. The cloud needs energy for its survival and obtains it from stars. When it comes near the sun to 'charge' its energy reservoir, a havoc is created on the earth and the novel describes how, with the help of scientists, all the nations club together and face the calamity. The administrators, the politicians, and the eccentric scientists are all deptictged very well. The fictional cloud of the novel turned out to have a realistic aspect too; when a few years later, through millimeter astronomy, clouds with molecules were detected by astronomers. (It is not yet known if there are any clouds with brains!) Indeed Hoyle once confessed that he was driven to write this novel when his scientific paper proposing the existence of giant molecular clouds was turned down by scientific referees on the grounds that such clouds could not exist in the interstellar space.

Hoyle has written quite a few science fiction novels. Some of them were written in collaboration with his son Geoffrey. The children's play. 'Rockets in Ursa Major' described above, was subsequently written

up as a novel by the father and son. *A for Andromeda and its sequel , The Andromeda Breakthrough* were novels that grew out of very successful televisions serials (and brought the then relatively unknown actress Julie Christie before the British audiences)**.In 1969, Hoyle was given the Kalinga Award by UNESCO, for popularizing science.**

In 1958, Hoyle became the Plumian Professor of Astronomy and Experimental Philosophy in the University of Cambridge. This Chair was earlier occupied by Arthur Eddington and Harold Jeffreys, both stalwarts in their respective fields. He felt, however, that the accelerated mode of astronomy research with growing collaborations between theorists and observers and with the increasing role of the electronic computer, needed a research institute in order to keep Cambridge at the apex of astronomical development. He therefore worked hard for and ultimately succeeded in establishing in 1966, the Institute of Theoretical Astronomy (IOTA). IOTA indeed proved to be a great success and was later expanded to include observational astronomy as well. In 1972, he was knighted by the Queen. It was largely due to his stewardship as the Chairman of the Anglo-Australian Telescope (AAT) Board, that the Anglo Australian Telescope was successfully commissioned.

But, though very well-known and distinguished, and creator of institution, Hoyle was never a part of the establishment. Because, to be established, one requires a conformist attitude. Hoyle, by nature had the stubbornness proverbially associated with his native county of Yorkshire. So, even though he worked on different committees, he kept aloof from the establishment.

In 1972, following a policy disagreement, he resigned directorship of IOTA, as well as the Plumian Chair and his natural love for hiking in the hills, prompted him to live in a small village in the Lake District. Living like a recluse and without any formal day-to-day connection with any institution, he still kept his research going.

In the mid-1970s. Hoyle created another controversy by challenging the generally believed ideas of terrestrial origin of life and its Darwinian evolution. With his former student Chandra Wickramasinghe he proposed a theory of extraterrestrial origin of life. This theory requires that bacteria and viruses enter the earth's atmosphere on cometary tails and may have seeded life on the earth four billion years ago. Although severely attacked by biologists and astronomers, their theory is now gaining more support. Ironically, he passed away while an Indian balloon experiment testing this hypothesis of panspermia had been successfully completed and its results are being analysed.

In spite of all this controversy, even his critics admit his unique creativity, originality and extraordinary perception. It would not be an exaggeration to call this extraordinary personality, the Galileo of modern times.

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PROFESSOR SIR FRED HOYLE [1915-2001]

Cardiff Centre for Astrobiology;
Fred Hoyle; Researching Panspermia and the Origins of Life

Obituary

by

Chandra Wickramasinghe

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Throughout a long and distinguished career stretching over six decades Sir Fred Hoyle sought to answer some of the biggest questions in science: How did the Universe originate ? How did life begin? What are the eventual fates of planets, stars and galaxies ? More often than not he discovered answers to such questions in the most unsuspected places. For instance he discovered that the secret of how stars evolve lay in a certain property of the carbon nucleus, a property (a resonancne) that was not discovered until Fred himself had pointed to its absolute necessity.

Fred believed that, as a general rule, solutions to major unsolved problems had to be sought by exploring radical hypotheses, whilst at the same time not deviating from well-attested scientific tools and methods. For if such solutions did indeed lie in the realms of orthodox theory upon which everyone agreed, they would either have been discovered already, or they would be trivial.

Fred Hoyle had no respect for the boundaries between scientific disciplines which were artificial social constructs that often stood in the way of a proper comprehension of the cosmos. The Universe does not respect the differences between physics, chemistry and biology, he would say, and his career in astronomy progressively embraced all these disciplines. With meticulous attention to detail he proceeded to master whatever discipline was needed in order to explore the Universe. Nor was Fred ever daunted by the enormous difficulty of some of the problems he tackled. With resolute determination and a fearless independence of mind he devoted a lifetime to understand the world in which we live.

Fred Hoyle will also be remembered as one of the greatest popularizers of science in the 20th century, following in the distinguished traditions H.G. Wells, James Jeans and Arthur Eddington. He had a rare gift of explaining complex scientific concepts in the simplest of terms, and in so doing he never failed to captivate huge audiences on radio, TV, public lectures as well as through his popular books. In 1950 he gave an historic series of radio talks on the BBC Third program (which was later published as a book entitled The Nature of the Universe.) Millions of listeners and readers of Fred Hoyle the world over admit to being enticed into science by the power of his arguments and his inimitable style of exposition. He was much admired and loved by the scientifically literate public in Britain and abroad.

Fred's more serious scientific work served as an inspiration to three generations of astronomers. Many of us would ungrudgingly acknowledge our debt of gratitude to Fred as one of the most creative and imaginative scientists of our times, one who taught us by his example to explore the world and search for Truth objectively and fearlessly, without prejudice, being guided only by the compelling trajectory of logic. He often condemned the enormous social pressures that are brought to bear on scientists nowadays to conform. He sneered at the modern practices of peer review and science umpiring conducted by journals, declaring them to be an invitation to unconstructive conformism, an impediment to the progress of science. In expressing such forthright views of the modern science he was criticized by the scientific establishment and he made many enemies.

Fred's contributions to astronomy are monumental and far-reaching. Although he might be best remembered for his more daring scientific pursuits – his unorthodox cosmology and more recently his support of panspermia, there is scarcely an area of astronomy that has not been touched in some way by his genius. Very often modern astronomers are unaware that areas of their own speciality rest firmly on foundations laid by Fred Hoyle several decades ago. Fred Hoyle's work on nucleosynthesis in collaboration with William A. Fowler and Geoffrey and Margaret Burbidge led to our present day understanding of the origin of chemical elements in stars. It was Fred Hoyle's original prediction of the presence of an excited state of the nucleus of the atom Carbon via his studies of the structure and evolution of stars that heralded a long and profitable collaboration with Caltech nuclear physicist Willy Fowler.

In the 1940's Fred Hoyle collaborated with R.A. Llyttleton and Hermann Bondi laying the foundations of the theory of accretion – the mechanism by which stars "suck in" nearby interstellar matter. A little later he had worked out a theory of how interstellar clouds can break-up into fragments to form stars, which again forms the basis of all modern theories of the formation of stars.

In the 1950's Hoyle, together with Hermann Bondi and Thomas Gold propounded the Steady-State Theory of the Universe. This was to challenge the then fashionable cosmological theory that supposed the Universe to begin with the explosion of a super atom some 15 billion yeas ago. Hoyle and his colleagues found such a theory philosophically unsatisfactory-it could not for instance answer the question: what was there before the initial explosion? In order to denigrate the theory that he disliked Fred conined the term "Big Bang Cosmology", a term that has stuck for nearly half a century.

Throughout the 1950's and 1960's a fierce battle raged between the proponents of the two schools of cosmology: Steady State us Big Bang. I was privileged to come to Cambridge as Fred's research student in 1960 and witnessed the scientific-sociological struggle between two rival camps first hand. With the flimsiest of evidence, particularly from studies of Radio Galaxies by Martin Ryle at Cambridge, each side was making strong claims for itself and the debate turned bitter and acrimonious at times. The discovery of a background of microwave radiation in the Universe by A. Penzias and R. Wilson in 1964 tipped the balance strongly against the original version of the Steady-State Universe, the radiation being explained as the cooled off relic of the heat of the Big-Bang. Hoyle together myself and Jayant Narlikar did not accept this data to be a defeat for the Steady State, and have indicated many reasonable ways in which the background radiation can be produced without a Big Bang. For instance the light of galaxies could be absorbed by iron whiskers expelled from supernovae and these whiskers then emit microwaves. In a recent book by Hoyle, Narlikar and Burbidge A Different Approach to Cosmology, a revised form of the Steady State

Theory, known as the “Quasi-Steady State Cosmology" is shown to be fully consistent with all the astronomical observation.

Fred’s collaborations with me span over some 40 years. In 1962 Fred Hoyle and I sought to understand the nature of cosmic dust, those gigantic clouds of obscuring matter that could be seen in photographs of the Milky Way. At the time we began our researches the generally accepted view was that these cosmic dust particles are similar to the micron sized ice crystals found in the cumulous clouds of the Earth’s atmosphere. We challenged this paradigm by showing that carbon particles are a more plausible model for the dust, and over the years astronomers have come to accept this carbon(graphite) grain theory as being close to proven. We ourselves moved on from inorganic carbon dust to organic dust and finally to biological particles for the composition of the interstellar dust. In 1977 Hoyle and I arguged that the origin of life on Earth must have involved the importation of viable cells from space, thereby challenging another Holy Grail of Science “The Primordial Soup Theory” for the origins of life. At first this theory, known as panspermia, was regarded as heretical but new evidence from many directions appears be moving towards a vindication of this point of view. Last month the first evidence of microbes at the edge of the Earth’s atmosphere at 41 km was presented in a paper to a meeting of the Society of Optical Engineering. Fred himself was unable to see the final form of this paper although he was a co-author and mentor of this work. Now, 34 years on, some form of panspermia theory of life’s origins appears to be gaining ground

Perhaps the most controversial aspect of Fred’s work involves the ideas of pathogrnic bacteria and viruses arriving from space, and that the evolution of life may be directed from outside. This work has raised fierce hostility in some circles, and the hostility is sometimes irrationally intense.

Fred has sometimes been unfairly presented as one who courts controversy for the sake of it. My knowledge of Fred as a friend and colleague over 40 years convinces me that this criticism is unfounded. Fred was always the most charitable of people and he never failed to acknowledge debts to earlier work or to others wherever they were due. In his more unorthodox scientific ventures he simply pursued the path that logic led him, or so he thought. Sometimes his intuition may have been wrong, but more often he has turned out to be right. On the biggest questions of the Origin of the Universe and the Origin of Life the last word has surely not been said, and Fred Hoyle would have been the first to admit that.

Although Fred Hoyle paid little attention to accolades, awards and approbations, he has received many honours and distinctions in his time. He was awarded the UN Kalinga Prize for the popularizaiton of science in 1968. In 1997 the Swedish Academy of Sciences awarded him the Crafoord Prize designed to honour work in fields that were not eligible for the Nobel Prize. He was a Fellow of the Royal Society, Foreign Associate of the US National Academy of Sciences, a Vice President of the Royal Society, and the President of the Royal Astronomical Society, and he was knighted by Her Majesty the Queen in 1972. He was an Honorary Fellow at both St Johns College and Emmanuel College Cambridge, and an Honorary Professor at Cardiff University since 1975.

His death will be a sad personal loss to those of us who were closely associated with him, and the world of science will be the poorer place for his passing.

He leaves his widow Barbara, son Geoffrey and daughter Elizabeth.

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Home Is Where the Wind Blows

Chapters from a Cosmologist's Life

An Autobiography
by
Sir Fred Hoyle

Views and Comments

"a rollicking good read"
One of this century's most eminent scientist offers a revealing and charming account of his life and work. Mathematician, physicists, astronomer, cosmologist and originator of the term the 'Big Bang'-Sir Fred has always been ready and able to challenge established thinking.

"A compelling, beautifully written, and rollicking good read it is… All working astronomers and others seeking rich and controversial insights should read this book." —Science

"Above all, a charming autobiography." —Sky & Telescope

"No one should go without this book who wants a whiff of the excitement that can come from telling friend from foe, doing science, struggling with great questions, seeing how the Universe works." —John Archibald Wheeler, Princeton

"Hoyle blazes bright, as human being and scientist." —Publishers Weekly

"Every astronomer will want to read this work, and those who do will be well rewarded." —Nature

Sir Fred Hoyle is one of the century's most eminent scientists, and this engaging book offers a revealing and charming account of his life.

Mathematician, physicist, astronomer, cosmologist – Sir Fred is perhaps best known for his brilliant explanation of the origin of the elements from hydrogen nuclei in stars, and for developing (with Sir Hermann Bondi and Thomas Gold) the elegant but controversial steady-state theory of the Universe. He coined the phrase 'Big Bang' to characterize the competing expanding-Universe theory, which ironically has gone on to become the dominant paradigm.

In this memorable account, we see how Fred Hoyle's childhood independence enabled him to challenge established thinking, and to meet many of the great figures of the age. This book will attract those who are interested in the development of science this century as well as general readers with an interest in autobiography.

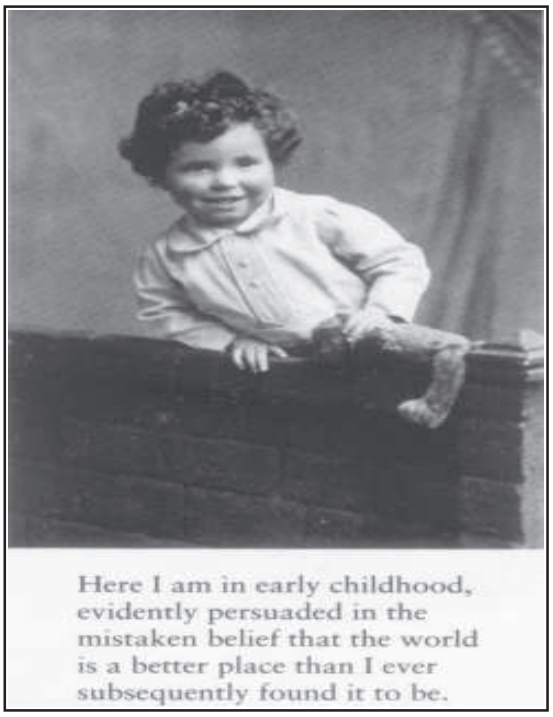
"Hoyle has had a major influence on the scientific thought of the second half of the 20th century. Here is a compelling account of the successes and tribulations of that life."

Bernard Lovell, New Scientist

"Fred Hoyle has for five decades questioned entrenched dogma and replaced it with reasoned alternatives. What good fortune to have this beautifully written autobiography of one of this Century's leading scientists.

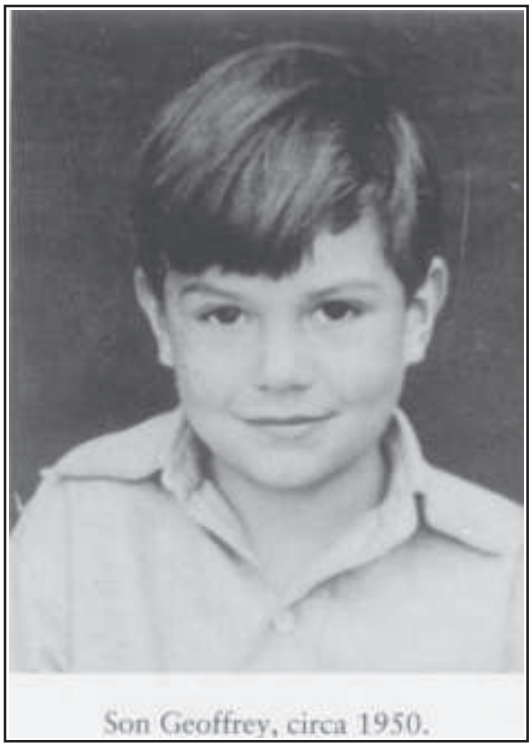
Nature

Some of the Photographs of Sir Fred Hoyle appeared in his Autobiography "Home Is Where the Wind Blows



Here I am in early childhood, evidently persuaded in the mistaken belief that the world is a better place than I ever subsequently found it to be.

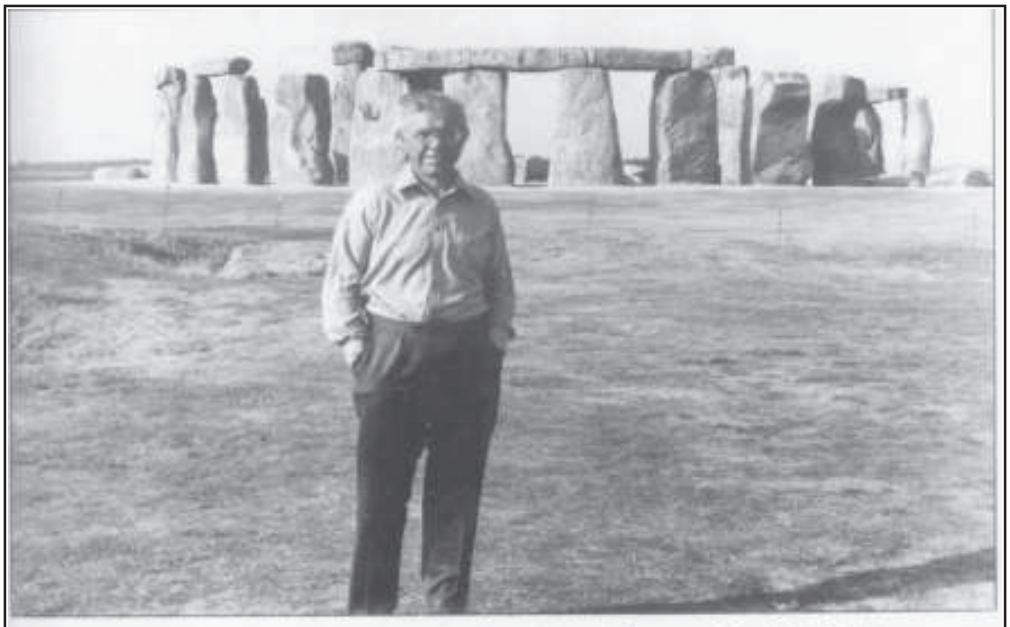
Geoffrey with daughter Elizabeth, circa 1950.



Son Geoffrey, circa 1950.

A portrait of my mother and me, from a fragment of a photograph that my father carried in his pocketbook in the trenches of the First World War.

Approaching the age of seven, with my sister.



On a visit to Stonehenge, at the age of sixty. (*Photograph by Philip Daly.*)

Barbara Clark: The actress in the play that consumed my life was suddenly on stage.

With my daughter Elizabeth, circa 1960.

With the formidable Geoffrey Burbidge.
(*Photograph by B. Gallagher.*)

My father, in 1915 (at the time of his recruitment into the British Machine Gun Corps).

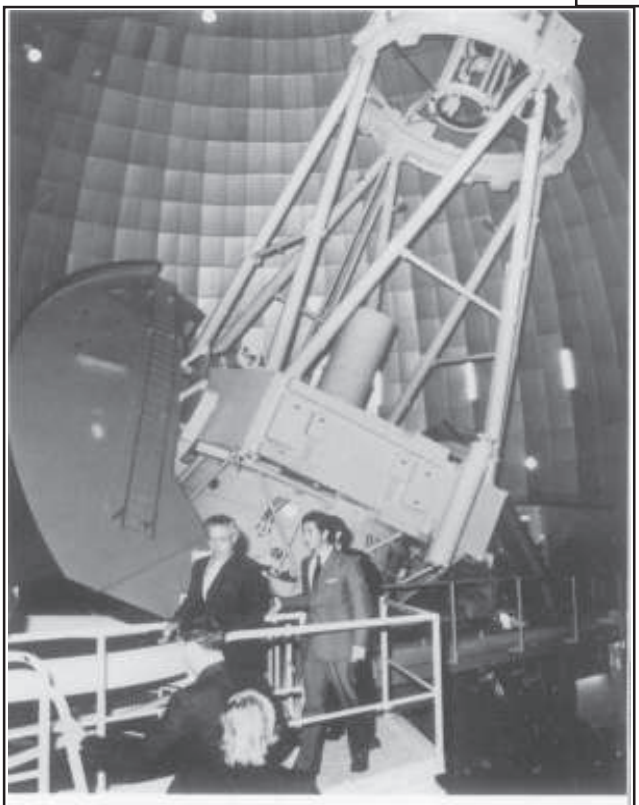
My mother, in a photograph taken in the early 1900s.

In my late forties. An early back injury makes it difficult for me to work comfortably at a table.

With Prime Minister Harold Wilson.
(Photograph courtesy of University of Bradford.)

Ben Preston (1819–1902), my great-grandfather. He was said to have written the well-known hymn "Onward Christian Soldiers."

A difficult problem. With Tommy Gold and Don Clayton, 1976. (*Photograph by D. D. Clayton.*)



The dedication of the Anglo-Australian Telescope, with Prince Charles, 1974. (*Photograph by M. Jensen.*)