International Journal of Astrobiology 1 (2): 77–78 (2002) Printed in the United Kingdom
DOI: 10.1017/S1473550402001118

Editorial

The Beginnings of Astrobiology

With the present surge of interest in astrobiology and its emergence as a new scientific discipline in its own right, the role of a celebrated pioneer is all too often forgotten. There can be little doubt that the late Sir Fred Hoyle played a key part in relating astronomical phenomena to questions of life. One of his first contributions in this area was his introduction of the so-called anthropic principle to astronomy. By the late 1940's astronomers had worked out how the simplest chemical element Hydrogen could be converted into Helium in stars, thus providing the main energy source by which stars shine. The building of nuclei beyond Helium by stellar nuclear processes appeared difficult at the time because of instabilities in nuclei with atomic masses 5 and 8. Hoyle had the grand vision of making most if not all of the elements in the Periodic Table in stars. In the early 1950's Hoyle argued that by the very fact of our existence, the existence of life, the element Carbon had to be synthesised in quantity in stars. This could not happen, Hoyle concluded, unless the nucleus of Carbon possessed an energy level corresponding to a hitherto unknown excited state which he was able to calculate. This was necessary so that three Helium nuclei could combine first to form a Carbon nucleus in the excited state that subsequently decayed into the ground state. One of the major triumphs of Hoyle's Anthropic Principle was that his predicted excited state was subsequently discovered in the laboratory by Ward Whaling and Willy Fowler at Caltech. This discovery opened the door to a brand new discipline of Nuclear Astrophysics. In a seminal paper published in 1957, Hoyle together with Willy Fowler, Geoffrey and Margaret Burbidge showed that all the chemical elements needed for life C, N, O, P, Mg, Fe, S … were made in stars. In a sense Hoyle's work in 1957 already provided the foundation stone for astrobiology. He showed that in essence we were made of stardust.

Fred Hoyle was amazingly prescient in recognising the importance of molecules in interstellar space even in the 1940's. Long before the discovery of the 21 cm line of neutral Hydrogen by Radio Astronomers Hoyle had argued for the widespread occurrence of Hydrogen molecules in the galaxy. Over two decades had to elapse before H_2 was discovered observationally and shown to be a major component of interstellar clouds.

In 1924 the Russian A.I. Oparin had promulgated the Primordial Soup Theory of the origin of life, and the same theory was independently proposed by the English Biologist J.B.S. Haldane in 1929. Hoyle admitted to being suspicious of Haldane's theory from the outset, as indeed he was of his politics! As early as 1955 in his classic book *Frontiers of Astronomy*, Hoyle discussed the merits of expanding the setting for the primordial soup to encompass the entire solar nebula, thus enhancing enormously the chances of life emerging from non-living material.

With the discoveries of carbon-based molecules in space, Hoyle and I began to

consider even grander cosmic vistas for life. In the mid-1970's we argued that complex organic polymers would form on the surfaces of interstellar dust. We referred to polyformaldehyde, polysaccharides, bicyclic and polycyclic aromatics as prebiotic components of dust, identifying these classes of substances by infrared and ultraviolet spectral features. Although our own identifications in the 1970's were refuted at the time, similar identifications of organic and prebiotic polymers in interstellar dust are now generally accepted without dissent. By 1980 Hoyle and I made out a case for over 20 % of interstellar carbon to be in the form of dust grains that mimicked the properties of freeze-dried bacteria. In view of the efficiency of conversion that was demanded by the astronomical observations we argued further that these organic dust particles most probably had a biological provenance. The idea was that comets condensing around primitive stellar-planetary systems inevitably mopped up a fraction of viable microbes from interstellar clouds, amplified them enormously in their warm watery interiors and returned most of it back into interstellar space from which new star systems can form. Some fraction of this biologically processed material would also find its way onto the surfaces of planets that could then be seeded with life.

With the explorations of Comet Halley in 1986 the simple model of an inorganic dirty ice comet had to be replaced by one that included a significant organic component. Once again astronomical observations revealed that the cosmic dust from this comet was largely indistinguishable from bacterial material or their degradation products.

These ideas – referred to as panspermia – are still controversial of course, but there are definite signs of progress towards an acceptance, albeit in a limited form. It is now generally conceded that organics in interstellar clouds and in comets played a decisive role in life's origins on the Earth. Moreover, it is accepted that microorganisms are sturdy enough to withstand the rigours of space travel, if suitably coated or encased, so transfers of life between comets and planets in the solar system are more or less taken for granted.

Fred Hoyle's visions for astrobiology remained for the most part unrealised throughout his lifetime. Now they are slowly coming to be accepted and may even be drifting into mainstream science. His priority in this area is amply documented and beyond dispute. In a lecture delivered in Cardiff on 15 April 1980 entitled "The relation of biology to astronomy" Fred Hoyle concluded thus:

"Microbiology may be said to have had its beginnings in the nineteen forties. A new world of the most astronishing complexity began then to be revealed. In retrospect I find it remarkable that microbiologists did not at once recognise that the world into which they had penetrated had of necessity to be of cosmic order. I suspect that the cosmic quality of microbiology will seem as obvious to future generations as the Sun being the centre of our solar system seems obvious to the present generation …"

Hoyle's prophesy may not be far from being realised.

Chandra Wickramasinghe
Cardiff Centre for Astrobiology
Cardiff University

References

Relevant technical papers are reprinted in "*Astronomical Origins of Life: Steps towards panspermia*" ed. F. Hoyle and N.C. Wickramasinghe (Kluwer Academic Press, 2000).

Popular exposition: "*Cosmic Dragons: Life and Death on our Planet*" - (Souvenir Press, 2001).