Panspermia According to Hoyle

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Chandra Wickramasinghe
The University of Buckingham

PANSPERMIA ACCORDING TO HOYLE

CHANDRA WICKRAMASINGHE
Cardiff Centre for Astrobiology, 2 North Road. Cardiff, CF10 3DY, UK

Abstract. Fred Hoyle's involvement in panspermia, recasting an ancient idea in a modern scientific framework marks an important turning point in the fortunes of this theory. Panspermia is discussed nowadays as a serious alternative to a purely terrestrial origin of life.

In the mid-1970's panspermia theories were thought by many to be on the fringes of science. The idea that life-seeds are distributed widely in the cosmos has ancient roots. It was discussed in some form in the writings of the Greek philosopher Anaxoragas in the 5th Century BC. It was also a widely held belief amongst Vedhic and Buddhist philosophers of the Orient at even earlier times. The revival of panspermia in a purely scientific context came about in the early 20th Century with the writings of Svante Arrhenius (1903). Arrhenius' ideas soon fell into disfavour, but for reasons that later turned out to be wrong. Becquerel (1924) and others used laboratory experiments to argue that bacteria would not survive the radiation environment of space, particulary ultraviolet radiation. It was later shown that microorganisms are not too easily destroyed by UV, but are mostly rendered inactive and that this process can be relatively easily reversed. Hoyle and I also argued much later that for bacteria in interstellar molecular clouds ultraviolet radiation poses no problem. Only a thin coating of condensed carbonaceous material around a bacterium would shield it from potentially damaging radiation. So Becquerel's original objections to panspermia turned out to be flawed.

Moreover, it has been amply demonstrated that that bacteria are resistant to a wide range of extreme conditions that would prevail in space, including their ability to withstand high doses of ionising radiation and extremely low temperatures. Despite all these developments the stigma against panspermia continued to linger well into the 1970's, the time when Fred and I began to work on these ideas.

It has often been remarked that Fred Hoyle rashly embarked on a campaign to re-instate panspermia. But the facts reveal a different story altogether. Fred and I had worked together on models of interstellar grains throughout the 1960s (Hoyle and Wickramasinghe, 1962, 1969).

By the late 1960's we had found that purely inorganic models of interstellar dust were difficult to reconcile with the observational data that was available. After Fred's resignation from Cambridge in 1972, his involvement with the AAT and his frequent trips to the USA led to a temporary cessation of our collaboration. When I had published a series of papers arguing for the presence of vast quantities of complex organic polymers in space I became a little uneasy about the profundity of the implications that might follow. Frightened perhaps by the prospect, I wrote Fred a series of letters with the seemingly outrageous proposition that the grains may be

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real live bacteria. After a long silence he responded from Cornell in what appeared to me to be a disappointingly negative way. He was exceedingly cautious in the way he approached this question, more cautiously than his critics have thought.

In the autumn of 1976 Fred was happy with the idea that interstellar dust contained the molecular building blocks of life that were subsequently mopped up by comets. This is in fact the limited version of panspermia that nowadays has come to be accepted almost without dissent – in striking contrast to the situation that prevailed in the late 1970's. In this respect at least Fred was 30 years ahead of his time. For a few years Fred held back from the proposition that interstellar dust (or a fraction of it) had a biological connotation. The first tentative steps towards biochemistry were thought to take place in interstellar clouds, but assembly of monomers into primitive living cells was considered to occur either within the interiors of hundred of billions of comets in the outer regions of the solar system, or even perhaps on the Earth (Hoyle and Wickramasinghe, 1976a,b)

It should be stated at this point that Fred's interest in the outer solar system as a nursery of life goes back to the 1940's when he embarked on a correspondence with biologist J.B.S. Haldane, the co-inventor of the primordial soup theory of the origin of life (Hoyle, 1994). In his classic book *Frontiers of Astronomy* (1953) Fred Hoyle already asserts a preference to the outer solar system for an origin of life on the grounds that there was vastly more carbonaceous matter available there.

The transition from prebioltic organics in the interstellar medium to bacterial grains came to us in slow stages. Firstly we argued that there is no logic to demand an origin of life on the Earth, and that the odds against such a purely terrestrial origin are superastronomical (Hoyle and Wickramasinghe, 1981). Secondly interstellar grains continued to exhibit properties that defied a proper explanation in terms of inorganic dust. Finally, through refinements of astronomical observations that continued though the 1970's the dust was found to possess properties that were indistinguishable from particles of bacterial composition (Hoyle et al., 1982; Hoyle, 1982). The infrared and ultraviolet properties of dust (Hoyle and Wickramasinghe, 1992) imply that about one third of all the interstellar carbon is tied up in the form of hollow organic particles with an uncanny resemblance to freeze-dried bacteria. Alternative non-biological explanations of this data seemed to Fred (and to me) to be highly contrived, and moreover, any such explanation was hard put to explain the astounding efficiency of conversion of inorganic matter to particles invariantly of bacterial size, shape and composition.

Since biological replication could not of course operate in the interstellar medium, we were led to suggest that amplification followed the cyclic processing of interstellar matter into stars, comets and planetary systems. The average timescale for this cyclic process is a few billion years. The overall logic of the scheme is illustrated in Figure 1.

Comets are thus regarded as the amplifying sites of cosmic microbial life. In the early days of the solar system comets contained radioactive materials that would have heated their cores and preserved a warm liquid watery environment

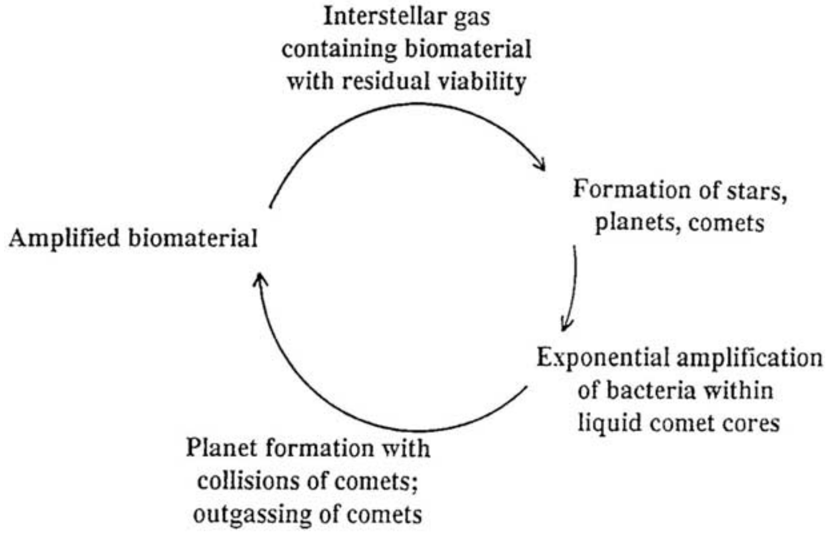

Figure 1. Cosmic life cycle.

for millions of years. Exponential amplification of microbes in such environments ensures that even the minutest surviving fraction, $<10^{-20}$ reaching a new comet forming stage in this cycle is thus vastly amplified. The logic of panspermia would then be inescapable.

In the years from the 1980's to the present various lines of evidence from a variety of disciplines have added greatly to the plausibility of panspermia. The antiquity of microbial life on the Earth has been pushed back to a time before 3.8 Gy (Mojzsis et al., 1996) when the Earth was being severely bombarded by comets and asteroids. In recent years the limits of microbial life on our planet have expanded to encompass an extraordinarily wide range of habitats. Microbes are found in geothermal vents, the ocean floor, in radioactive dumps and in Antarctic soil. Microorganisms have been recovered from depths of 8km beneath the Earth's crust, and laboratory studies have shown that bacteria can survive pressures at ocean depths of thousands of kilometres or more. The long-term survivability of bacteria has also been extended from 25 to 40 million years (Cano and Borucki, 1995) to a quarter of a billion years in the case of a bacterium entrapped in a salt crystal (Vreeland et al., 2001). Direct proof of the survival of bacteria exposed to radiation environments in the near Earth environment has also been demonstrated using NASA's Long Exposure facility.

The Hoyle-Wickramasinghe panspermia theory requires life to have been introduced to Earth for the first time by comets some 4 billion years ago, with an ongoing incidence of microorganisms continuing to the present day. Recent discoveries of organic molecules and fragile structures within the Mars meteorite ALH84001 have gone in the direction of supporting the idea that microbial life could indeed be transferred in viable form between objects within the solar system (McKay et al., 1996).

No amount of indirect evidence would convince the hardened sceptic, however. What is required is a direct demonstration that viable microbes exist within cometary material. Such *in situ* space experiments are indeed in train as a long-term objective of Space Science, although definitive results may be at least a decade away. In the mean time collections of cometary dust in the stratosphere may have already turned up with evidence that comes close to being decisive, so vindicating one of Fred's most daring and provocative scientific assertions (Harris et al., 2002; Wainwright et al., 2003).

I feel deeply privileged to have been Fred Hoyle's friend and accomplice in this endeavour.

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