in *Towards a Philosophy of Cosmic Life* (eds. D. Bartosch et al) Springer 2023

Admitting our inalienable links with the cosmos

Chandra Wickramasinghe

1.Buckingham Centre for Astrobiology, University of Buckingham, UK
2.Centre for Astrobiology, University of Ruhuna, Matara, Sri Lanka
3.National Institute of Fundamental Studies, Kandy, Sri Lanka
4.Institute for the Study of Panspermia and Astroeconomics, Gifu, Japan

Abstract

In this article we trace the progress of studies spanning many scientific disciplines that all converge on the conclusion that life is a cosmic phenomenon. The strong antipathy to accepting this conclusion is deeply rooted in a scientific culture that can trace back its antecedents to Aristotle in the 3rd century BCE, a culture that is Earth-centred in fundamental philosophy. The tenacity of scientific institutions in adhering to some form of the Aristotelean thesis of spontaneous against all odds, runs parallel with the still prevailing Judaic illusions of Heaven and Hell. A philosophy of cosmic life based on hard facts is long overdue.

1. Introduction

"An error does not become truth by reason of multiplied propagation, nor does truth become error because nobody sees it. Truth stands, even if there be no public support. It is self-sustained." - Mahatma Gandhi

The natural human instinct to seek a connection with the universe at large can be seen to have begun hundreds of thousands of years ago. An example is found in the Lascaux caves in southern France, with the Bull of Heaven – the constellations of Taurus - and Orion clearly portrayed as shown in Fig. 1. These connections, expressed in art, literature and sculpture, persisted for centuries, albeit in various stylised forms – eg. gods in the sky – throughout Babylonian, Egyptian, Persian and Greek civilization. A sharp reversal of these trends followed later, first from the advent of Christianity and then in the renaissance movements in the middle of the last millennium.

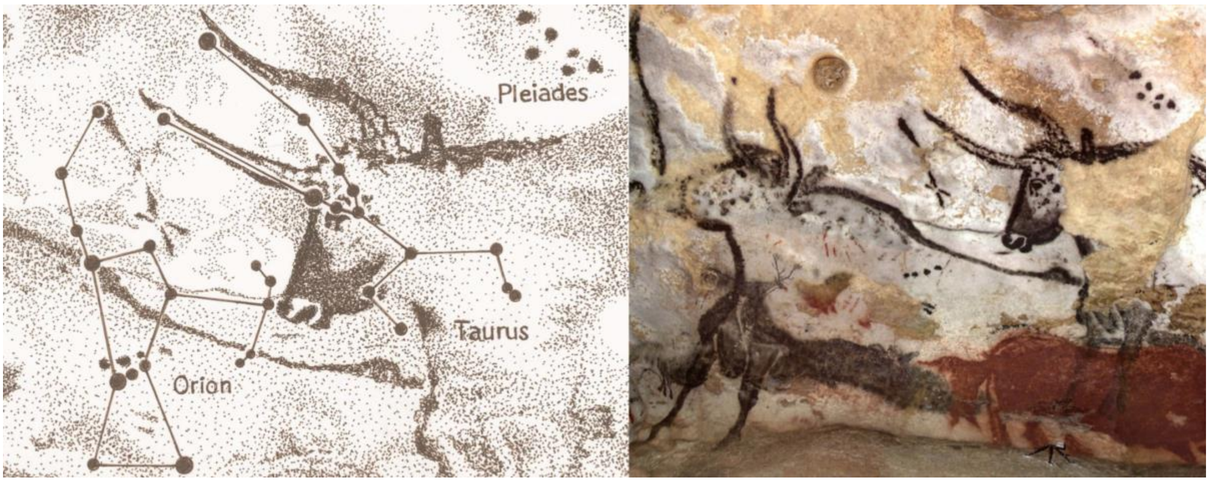

Fig. 1 Lascaux cave paintings over 12,000 years ago, showing connection between a bull and the constellation of Taurus.

In most ancient cultures throughout the world comets were regarded with reverence and awe. They were thought of as bringers of pestilence and death on the one hand, and of life and fortune on the other. In the present era, however, we tend to dismiss all such views as ignorant superstitions. When, together with Fred Hoyle, the present writer "revisited" comets from the late 1970's onwards and came to argue that aspects of such ancient superstitions might well be fortuitously true, we were often fiercely criticised (1-5). An unwritten rule of Western modern science appears to be that no vestige of a discarded ancient belief or sets of beliefs could be revisited, let alone revived.

Fig.2. Medieval depiction of comet causing disasters

From the 1970's onwards the present author, in collaboration with Fred Hoyle, and later with other collaborators, began to assemble a vast body of data and evidence to support panspermia from astronomy, geology as well as biology. New data and new facts continue to provide ample verification of prior predictions with ever-more compelling evidence pointing to the *inevitability* of panspermia as opposed to spontaneous generation as the mode of origin and propagation of life throughout the universe. We have argued from the 1980's through to the present day that comets are incubators and distributors of life in the form of bacteria and viruses throughout the universe. Today, whilst comets are conceded at long last as the repositories of complex organic molecules that may have contributed to spontaneous generation of life on the Earth, their role as carriers of life, despite a great deal of contrary evidence is still fiercely resisted in many quarters.

Over the past century or so astronomy has established beyond a shadow of doubt that the universe and Earth are inextricably linked at least in one regard. All the chemical elements that are present everywhere around us – the C, N, O in our bodies, the silicon in the rocks, the iron and other chemical elements that make up the huge multiplicity of objects and artefacts around us – were synthesised in nuclear reactions that take place in the deep interiors of stars (6). Although this proposition was disputed for a while it is now part and parcel of orthodox everyday accepted science. Over the past half a century or so it has been slowly emerging that our ancestry as living biological entities also resides in the stars (5,7,8).

2. Interstellar Dust

When the present author first came to investigate the nature of interstellar dust in 1960 the vast amounts of dust in the Milky Way were thought to be comprised of micrometre sizes ice particles, similar to the ice grains found in the cumulous clouds in the Earth's atmosphere. A re-examination of this earlier work soon led to the conclusion that this model of cosmic dust was wrong, and instead the theory was proposed that cosmic dust was made up mainly of the element carbon (1). The precise form of the carbon in cosmic dust was gradually unravelled by examining the light from distant stars that traversed through the dark clouds leaving spectroscopic signatures of their chemical make-up.

By the mid-1970's there was clear astronomical evidence for the widespread occurrence in the galaxy of organic molecules (5). At about this time infrared observations of interstellar dust were beginning to show spectral features in the mid and near-infrared which could not be easily reconciled with a combination of inorganic silicates and water-ice as was hitherto believed. But this evidence was vigorously disputed by our critics for a long time. Fred Hoyle and the present writer spent nearly 5 years of our professional lives modelling this data with biopolymers – polysaccharides, polyaromatic hydrocarbons in particular, and our pioneering work has at last been vindicated by a flood of data coming in from space telescopes and space probes I9, 10, 11)). The complex organic nature of the dust in interstellar space as well as in comets and meteorites is now beyond dispute (5).

The manner in which some of these organic molecules might relate to life and biology, however, remains a matter of controversy – one fuelled by cultural constraints rather than science. The question relates to whether these biologically relevant molecules represent steps towards life – prebiotic evolution – or whether they are the products of biological degradation – the detritus of life. The overwhelming bulk of the organic material found on Earth is the result of the decay of biology. So, the question we need to ask is this: Why is it not the same for the organics in space?

The currently fashionable idea is that the chemical building blocks of life may be delivered to a primitive Earth to form a "primordial soup" from which life thereafter is supposed to emerge through chemistry even against manifestly insuperable odds. My own position has been markedly different and has been guided by a long succession of discoveries in astronomy, geology and biology. The emerging view that is still being denied is that life is a truly cosmic phenomenon and arose on Earth following the delivery of bacteria and genetic components in the form of viruses by means of comets. On this picture the patterns of life's evolution witnessed on Earth must be reproduced on countess other planetary abodes – exoplanetary systems such as been shown to exist in their hundreds of millions in our galaxy alone.

2. Implications of accepting the concept of cosmic life

We live today in a world that is firmly centred on an anthropocentric and overwhelmingly Eurocentric viewpoint. The assertion of our self-importance as a species and as a superior tribe of humans has ramifications even in relation to our attitude to the non-human living world, as well as on our perceived right to exploit the latter in any manner we might choose fit. This is reflected even in our reaction to such issues as climate change and environmental degradation resulting from our conduct.

If it can be firmly established that we – as sentient living entities - are not alone in the Universe the implications for humanity will be profound. It could be even more important if we know that alien life in the form of microbes – bacteria and viruses - exist in our midst even now and continually rains down on our planet. Such microbes may sometimes cause devastating pandemics of disease as happened very recently with the Covid-19 pandemic (12); but more positively they have the potential to augment our genomes and over long intervals of time unravel an ever-changing panorama of cosmic life (13). In either case - whether as alien microbes in our vicinity, or alien intelligence on distant planets - the acceptance of the emerging facts of cosmic life will mark an important turning point in human history.

But how did life arise in the first instance? Not just on the Earth, but anywhere in the Universe? Does life emerge spontaneously on every Earth-like planet by processes involving well-attested laws of physics and chemistry from simpler chemical units such as nucleobases and amino acids even if all these can be delivered from space? Or did the first-ever origin of life involve an extraordinary unrepeatable event involving stupendous volumes of the universe in the most distant cosmological past? These age-old questions have recently acquired a new sense of urgency. As I have indicated the answers stare us in the face, but we tend to turn away because they are unpalatable, and demands a humiliating diminution of our status in the cosmos.

3. Exoplanets and Evidence of Extraterrestrial Life

The primary requirement for the emergence of life and subsequently of creatures like ourselves would be for the existence of rocky planets with water and an atmosphere generally similar to Earth. In 1995 Didier Queloz together with Michel Mayor discovered definite evidence of planets outside our solar system (14). The first of these so-called exoplanets orbited a star 50 light years away in the constellation of Pegasus; it was a giant planet with a mass similar to Jupiter located too close to its parent star for any life to be possible. In 2009 NASA launched its orbiting Kepler telescope, which was specifically designed to discover planets that are the size of Earth. The detection process involved tracking down minute blinks (dimming) in the star's light when a planet transited periodically in front of it during its orbit. At present nearly 4000 definite as well as probable detections of habitable planets have been made within only a very small sampling volume of our Milky Way. Most of these planets orbit red dwarf stars that are on the average twice the age of our sun. Extrapolating from the sample of present detections the estimated total number of habitable planets in our Milky Way galaxy is reckoned to be in excess of 100 billion (15). On many of these planets, one might speculate, that life may have begun, evolved, and perhaps long since disappeared.

Another related enterprise that has captured the news recently is the search for extraterrestrial intelligence using arrays of radio telescopes to scan the skies for evidence of intelligent signals. Over half a century ago Philip Morrison and Giuseppe Cocconi first drew attention to the possibility of searching the microwave spectrum of cosmic sources for intelligent signals and suggested particular frequencies as well as a set of potential targets. The SETI program (Search for Extraterrestrial Intelligence) began tentatively in 1960 and was first supported by NASA, and later by a host of private or semi-private entrepreneurs. With the exception of a single brief and mysterious "Wow!" signal discovered in August 1977 there has been a deathly silence across all of the prospective sources that been scanned.

There could be a case for saying that the lack of progress in this venture was the result of organisations like NASA backing off. This may have been the thinking behind Russian billionaire Yuri Milner's 100 billion-dollar SETI initiative that was recently announced with much pomp. Buying more telescope time, increasing the range of wavelengths, enhancing detector sensitivity and extending sky coverage have been argued as prerequisites if a breakthrough within a decade is to be achieved. It is also possible that we have the wrong strategy altogether in our SETI endeavours. Predrag Slepjevic and the present writer has recently argued that we may be looking in the wrong places for SETI (16). What if the ET messages are not in the form of electromagnetic radiation but coded messages in the DNA and RNA of viruses that already arrive on our planet? One way or another, a positive result from SETI would be contingent on the emergence and dispersal of primitive life capable of evolving into intelligent creatures such as ourselves.

4. Panspermia

How common is the phenomenon of life in the Universe? The answer to this question lies in the concept of panspermia – or cosmic life. The idea that microbial life springs up *de novo* on billions of Earth-like habitable planets is an unproven, and most likely erroneous proposition. Such a belief is an extension of the canonical "primordial soup theory" for life's beginnings on the Earth, which is a dogma with no hard evidence to support it. The dogma in turn can be traced back to the Greek Philosopher Aristotle (384-322BCE) who proposed that life arose spontaneously from inorganic, inanimate matter whenever favourable conditions prevailed – eg fireflies from a mixture of warm earth and morning dew! Unfortunately, because of his stature as a philosopher, Aristotle's views prevailed and still prevails almost to the present day. Experimental demonstrations against the validity of spontaneous generation have consistently been ignored in particular the 19th century experiments of Louis Pasteur showing that life at a microbial level is always derived from pre-existing microbial life.

If there was a deep principle of nature that drove inorganic systems towards the emergence of primitive life – bacteria rather than fireflies - the evidence for this would have long since been discovered in the laboratory. With calculations showing grotesquely low *a priori* probabilities for the transition from non-life to life only two options remain. The origin of life was an extremely improbable event that occurred on Earth (because we are here!) but will effectively not be reproduced elsewhere. In that case we would indeed be hopelessly alone. Or, a very much vaster cosmic system than was available on Earth, and a very much longer timescale was involved in an initial origination event, after which life was transferred to Earth and elsewhere by processes that present writer and the late Sir Fred Hoyle proposed many years ago - panspermia. The essence of our theory of cosmic life is that the entire galaxy – perhaps the entire Universe – is one single connected biosphere. Physical transfer involving exchange of meteorites, comets, and dust with an intermingling of genes on a cosmological scale is far more probable than independent life origination events that are assumed in conventional science.

4. The mind-blowing improbability of Life

The operation of a living system depends on thousands of chemical reactions taking place within a membrane-bound cellular structure – eg a bacterial cell. Such reactions, grouped into metabolic pathways, have the ability to harness chemical energy from the surrounding medium in a series of very small steps: transporting small molecules into cells, building long chain biopolymers of various sorts, and ultimately making copies of themselves while possessing a capacity to further evolve. Batteries of enzymes, composed of chains of amino acids, play a crucial role as catalysts precisely controlling the rates of chemical reactions. Without enzymes, and the specific arrangements of amino acids within the enzymes, there could be no life.

In present-day biology, the precise "information" contained in enzymes—the arrangements of amino acids into folded chains—is transmitted by way of the coded ordering of the four nucleotide bases (A,T,G,C) in DNA. In a hypothetical RNA world, that some biologists think may have predated the DNA-protein world, RNA is posited to serve a dual role as both enzyme and transmitter of genetic information. If a few such ribozymes are regarded as precursors to all life, one could attempt to make an estimate of the probability of the assembly of a simple ribozyme composed of 300 bases. This probability turns out to be 1 in 4^{300}, which is equivalent to 1 in 10^{180}, which can hardly be supposed to happen even once in the entire 13.9-billion-year history of the universe. And this is just for a single enzyme. In the simplest known bacterium *M. genitalium* with some 500 genes coding for enzymes the improbability escalates to a super-astronomical scale (eg ref. 5, 8, 13).

Over the past 50 years the most advanced laboratories in the world have continued to test the theory of spontaneous generation by attempting to synthesise an autonomous bacterial cell. The failure thus far to witness any trend whatsoever toward the emergence of a living system is often attributed to the infinitesimal scale of the laboratory system when compared with the terrestrial setting in which life is thought to have arisen. Yet, if we move from the laboratory flask to the oceans of the Earth, we gain in volume only a factor of about 10^{20}, and in time, from weeks in the laboratory to half a billion years, the gain is an additional factor of 10^{10}. In the probability calculation for the single ribozyme, we therefore gain a factor of 10^{30} in all, which reduces the improbability factor from 1 in 10^{180} to 1 in 10^{150}. A grotesque improbability remains, and that just for a single enzyme!

On this basis, it is very difficult to avoid the conclusion that the emergence of the first evolvable autonomous cellular life form was almost certainly a unique event in the cosmos. If this did indeed happen on Earth for the first time, as conventional Eurocentric wisdom tends to assert, it must logically be regarded as a near-miraculous event that would not be repeated elsewhere, let alone in any laboratory simulation of the process. To overcome improbabilities on the scale that is involved here, it stands to reason that one would gain immensely by going for the biggest system available—manifestly, the universe as a whole.

The argument that panspermia must be rejected because it merely transfers the problem of origin from Earth to another setting has no logical basis whatsoever. The question of whether life started *de novo* on Earth or was introduced from the wider universe is a fully scientific and precise question that merits investigation - one that is open to testing and verification. The invocation of Occam's razor to exclude a discussion of such matters is unfortunate and merely an excuse for keeping scientific discussion within the strict bounds of what is considered *de rigueur*. It is strikingly reminiscent of the kind of restrictions that stifled science in the Middle Ages.

Bold assertions that panspermia is invalid because viable bacteria and viruses cannot be transported in viable form across astronomical distances is a striking example of the wrong and inappropriate use of "Occam's razor". Despite claims to the contrary, the weight of scientific evidence does indeed favour survival of bacteria under space conditions to at least to the extent that makes viable interstellar transfers of life inevitable. We do not require more than one in 10^{24} iterant microorganisms to survive, until it becomes incorporated in a planet/comet forming event in which a new cycle of exponential amplification occurs; a few viable microbes then turning into trillions. The strong feedback loop of cosmic biology is depicted in Fig.2.

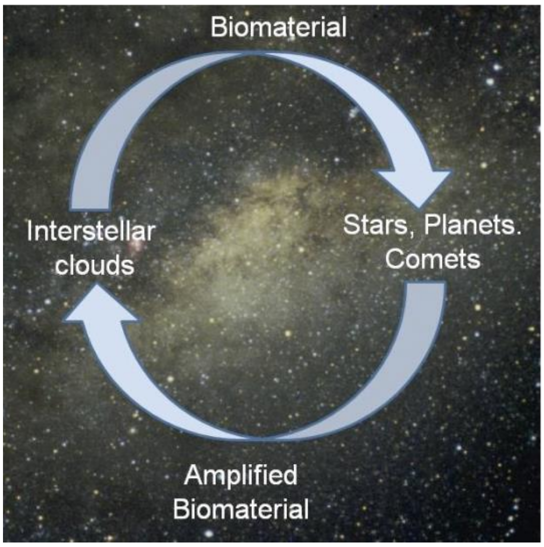

Fig.3. Bacteria expelled from a planetary system are amplified in the warm radioactively heated interiors of comets and thrown back into interstellar space

This exceedingly modest requirement of microbial survival would be impossible to violate particularly for freeze-dried microorganisms embedded within particles of interstellar dust. The vast majority of bacteria in interstellar space does not and need not persist in viable state. Interstellar clouds would thus be filled overwhelmingly with the detritus of life which takes the form of genetic fragments that could include viruses as well as a wide range of organic molecules.

6. Direct spectroscopic proof

It would be false modesty to maintain that the late Sir Fred Hoyle and the present writer were not directly responsible in large part for the revival of panspermia in the form it is being discussed in 2022. Our proposal was that trillions of cometary bodies in the cosmos serve as the long-term reservoirs and repositories of cosmic biology, evidence for which shows up in comets as well as in the all-pervasive interstellar dust in the universe as we have already noted.

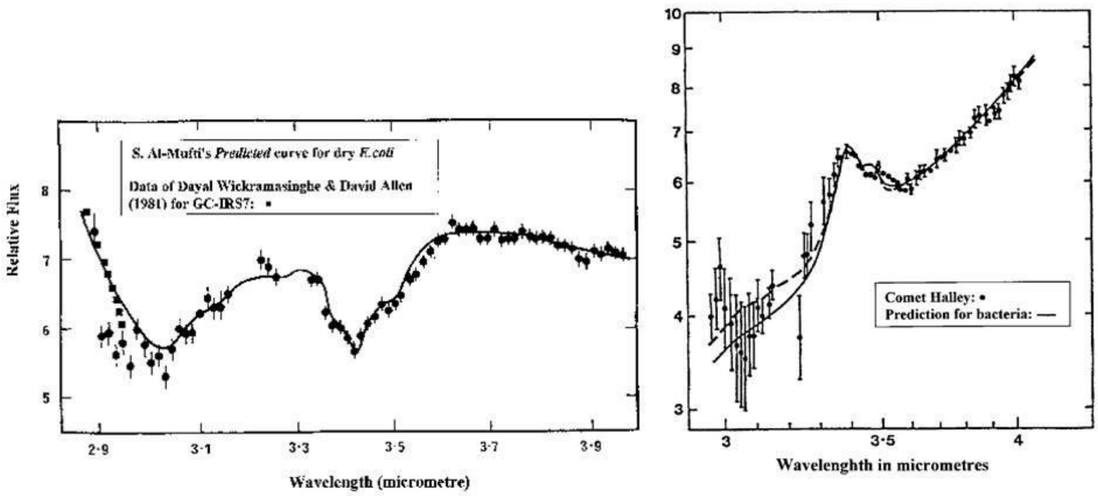

Fig. 4 Left panel: Comparison of the normalized infrared flux from the Galactic Centre infrared source GC-IRS7 with the laboratory spectrum of *E coli*. Right panel: Emission by dust coma of Comet Halley observed by D.T.Wickramasinghe and D.A. Allen on March 31, 1986 (points) compared with normalized fluxes for desiccated E-coli at an emission temperature of 320K. The solid curve is for unirradiated bacteria; the dashed curve is for X-ray irradiated bacteria.

The right-hand panel of Fig.3 relates to the next key development that took place in 1986 was the return of Halley's comet after 76 years. This was the first comet that came under close scrutiny after the dawn of the Space Age. The popular view at the time was that comets were dirty snowballs (Whipple's dirty snowball comet) came to be demolished fairly quickly by observations that were made in April 1986 using satellites as well as ground-based telescopes. Before the actual rendezvous of the Giotto Space Probe with Comet Halley in April 1986 nobody had ever seen the nucleus of a comet – only their spectacular tails were seen and photographed, and people had to theorise and conjecture as to the existence and the nature of the comet's nucleus or core. Ahead of the observations of 1986 being made, Fred Hoyle and one of us (NCW) made a firm prediction that our organic comet model when it was heated in sunlight near perihelion (closest approach to the sun) would boil off bacterial dust and turn into a black coal-like body. This prediction was dramatically verified. Moreover, an infrared spectrum of the comet's dust tail was found to match the spectrum of a bacterium to an amazing degree of precision. This is demonstrated in the right-hand panel of Fig.3 (4,7).

Since 1986 a wealth of data has accumulated relating to other comets, from ground-based telescopes as well as space probes, and these have been extensively reviewed in a long series of scientific papers and books. In no one instance could we find any contradiction with our biological model of comet dust, although astronomers are still loath to admit the fact. The latest Rosetta space probe to the comet 67P/CG has generated a wealth of data that can only be explained satisfactorily on the basis of a biological model of the dust (Fig.4) (17). Fig. 4 shows the close consistency between the surface properties of the comet 67P/C-G and the spectrum of a desiccated bacterial sample.

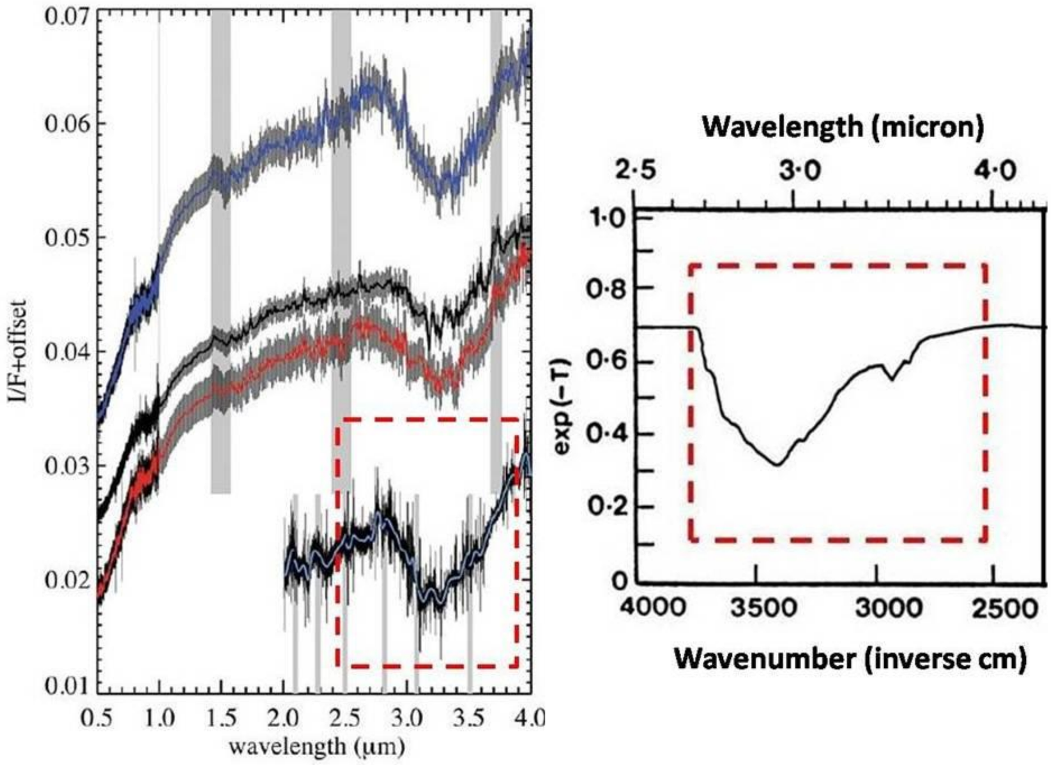

Fig. 4. The surface reflectivity spectra of comet 67P/C-G (left panel) compared with the transmittance curve measured for *E-coli* (right panel).

One aspect of cometary behaviour that might serve to decide critically between a biological and non-biological model was already stressed by Wickramasinghe, Hoyle and Lloyd nearly 25 years ago (18). This is the profuse emission of gas and dust occurring for some comets in the cold depths of space far beyond the orbit of Jupiter. At such distances both thermal evaporation and surface detonation of chemical processes would be ruled out. The first such phenomenon was discovered for Comet Hale-Bopp erupting at a distance of 6.5AU in 1983/84 long before it had reached perihelion in April 1997. More recently in 2015 Comet Lovejoy, erupting much closer to the sun at 1AU distance, emitted vast amounts of a sugar and ethyl alcohol which are natural products of fermentation (19). The ethanol and sugar thus released amounted to an alcohol equivalent of 500 bottles of wine every second – plausibly the products of fermentation in subsurface liquid domains of the comet!

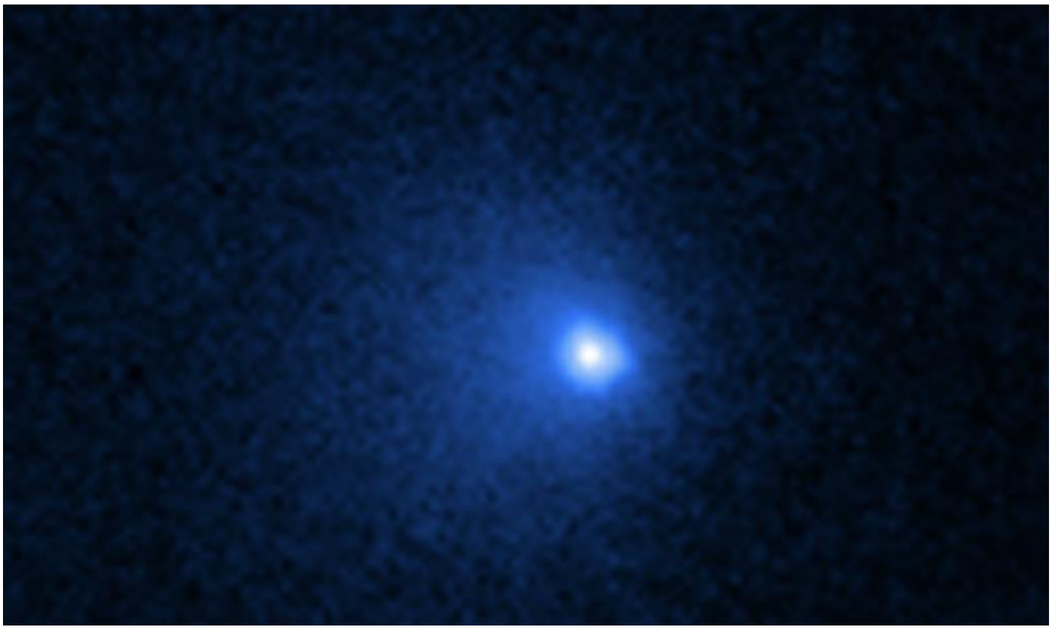

Fig.5. The giant comet (C/2014 UN271) imaged with the Hubble Space Telescope in January 2022 (Courtesy of NASA)

More recently the discovery of a giant comet (C/2014 UN271) some 100km in diameter at a distance of 29AU in October 2014 and the later discovery in September 2021 of a dramatic brightening episode offers a further opportunity for verifying the predictions of fermentation processes in a “biological” comet (20) The eruptions of the comet at a heliocentric distance of 20AU (two thirds of the distance from the sun to Neptune) can only be plausibly explained as due to high pressure venting of the products of microbial metabolism in radioactively heated subsurface lakes. It is currently (in January 2022) active even further out near the very edge of our planetary system. The standard non-biological model of comets is woefully inadequate to account for eruptions at such large distances from the sun where surface temperatures are as low as 60K (20). Despite all such strongly supportive data there appears to be a concerted effort on the part of a majority of scientists and science journalists to assert that although life-related organic molecules have been found in large quantity in comets they cannot be interpreted as signifying life.

7. Geological evidence supporting panspermia

Three decades ago the earliest evidence for microbial life in the geological record was thought to be in the form of cyanobacteria-like fossils dating back to 3.5 Ga ago. From the time of formation of a stable crust on the Earth 4.1 Ga ago following an episode of violent impacts with comets (the Hadean Epoch) there seemed to be available a 800 million years timespan during which the canonical Haldane-Oparin primordial soup and the spontaneous generation of life may have arguably developed. Very recent discoveries, however, have shown that this time interval has been effectively closed. Ancient rocks laid down 4.1-4.2 billion years ago belonging to a geological outcrop in the Jack Hills region of Western Australia have been found to contain micron-sized graphite spheres with an isotopic signature of biogenic carbon locked away within crystals of zirconium (21). Such signatures of fossil bacteria were deposited at a time when the collisions of the Earth with comets and asteroids were happening at a relentless pace.

Fig.5 Micron-sized carbon blobs with biogenic carbon isotope ratio within a zirconium crystal in the Jack Hill's outcrop. Size of a carbon sphere is about 1 micrometre. (Courtesy, Stanford UCLA)

This latter discovery in my view puts paid to the possibility of any primordial soup brewing on Earth because these fossils were deposited at a time when the planet was being relentlessly bombarded by comets and meteorites

The requirement now, on the basis of orthodox thinking, is that an essentially instantaneous transformation of non-living organic matter to bacterial life took place, a proposition that strains credibility of Earth-bound abiogenesis to its utmost limit. A far more plausible proposition is that fully-developed microorganisms arrived at the Earth via impacting comets, and these became carbonized and trapped within ancient rocks.

8. Distribution of habitable exoplanets and exchanges of living entities

We have already pointed out that at the present time nearly 4000 definite as well as probable detections of habitable planets have been made within only a very small sampling volume of our Milky Way (15). Most of these planets orbit red dwarf stars that are on the average twice the age of our sun. Extrapolating from the sample of detections in our local vicinity the estimated total number of habitable planets in the entire Milky Way galaxy is reckoned to be in excess of 100 billion. *Proxima Centauri b* (also called *Proxima b*) is closest habitable exoplanet orbiting the red dwarf star Alpha Centauri at a distance of some 4.2 light years from the Sun. (Fig.6).

Whilst comets could supply a source of primitive life (bacteria, viruses and genes) to interstellar clouds and thence to new planetary systems and embryonic exoplanets, the genetic products of evolved life (local evolution) could also be disseminated on a galaxy-wide scale (22). At the present time our planetary system, which is surrounded by an extended halo of some 100 billion comets (the Oort Cloud) replete with microbial content as we have seen, moves around the centre of the galaxy with a period of 230My (Fig.7). Every 40 million years, on the average, this cloud of comets in our solar system becomes gravitationally perturbed due to the close passage of a giant molecular cloud. Such gravitational interactions lead to hundreds of comets from the Oort Cloud being thrown into the inner regions of our planetary system, some to collide with the Earth. Such collisions do not only cause extinctions of species (as one impact surely did 65 million years ago, killing the dinosaurs), but they could also result in the expulsion of surface material back into deep space (22).

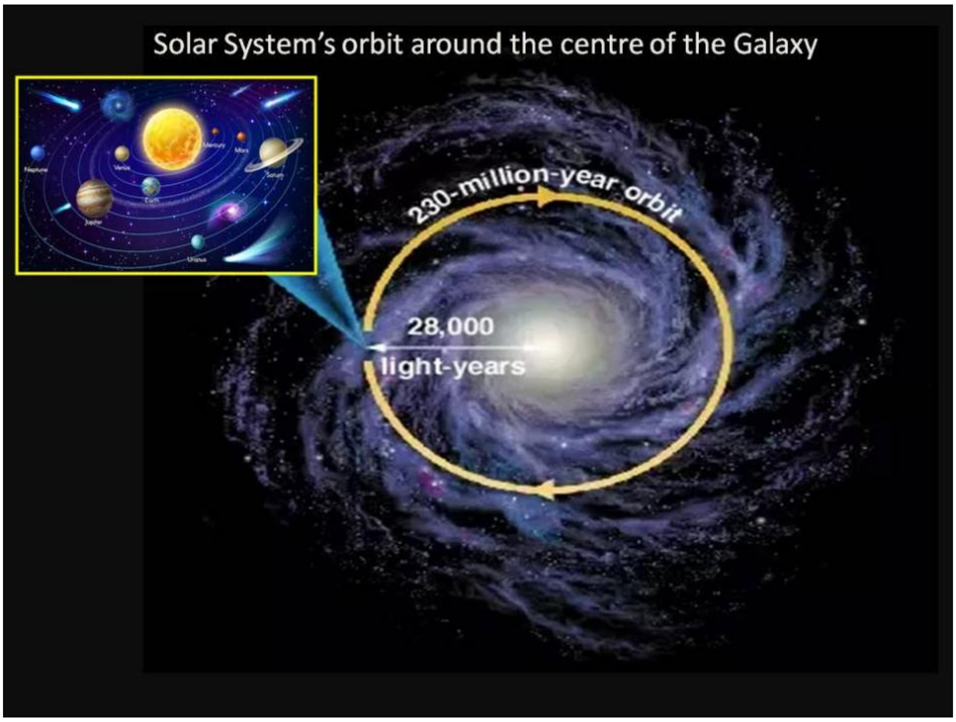

Fig.7 Schematic path of the solar system around the centre of the Galaxy

A mechanism can thus be identified for the genes of evolved Earth-life to be transferred to alien habitable exoplanets. A fraction of the Earth-debris so expelled survives shock-heating and could be laden with viable microbial ecologies as well as genes of evolved life. Such life-bearing material from the Earth could reach newly-forming planetary systems in the passing molecular cloud within a million years of the ejection event. A habitable exoplanet could then become infected with terrestrial microorganisms and terrestrial genes that can contribute to the process of local biological evolution.

Once life has got started and evolved on an alien planet or planets of a new system, the same process can be repeated (via comet collisions) transferring a new compliment of genetic material carrying local evolutionary 'experience' to other molecular clouds and other nascent planetary systems. If every life-bearing planet transfers genes in this way to more than one other planetary system (say 1.1 on the average), with a characteristic time of 40My then the number of seeded planets after 9 billion years (lifetime of the galaxy) is $(1.1)^{9000/40} \sim 2\times10^9$. Such a large number of 'infected' planets illustrates that Darwinian evolution, involving horizontal gene transfers, must operate not only on the Earth or within the confines of our solar system but on a truly galactic scale. Life throughout the galaxy on this picture would inevitably constitute a single connected cosmic biosphere.

9. Meteorites, micrometeorites and cometary bacteria

When a life-bearing comet makes its repeated orbits around the sun its volatile material with an entrained component of bacteria and viruses are progressively peeled away. Carbonaceous chondrites that occasionally fall to Earth represent fragments of comets denuded of volatiles but retaining a residue of silicates and more robust organic structures, possibly fossilised microbial forms.

The topic of microfossils in carbonaceous chondrites has sparked bitter controversy ever since they were first discovered in the 1960's by Claus, Nagy and Europa (23). Since carbonaceous chondrites are generally believed to be derived from comets, the discovery of fossilised life forms in carbonaceous meteorites would provide strong *prima facie* evidence in support of the theory of life in comets and cometary panspermia. However, some contamination was discovered in early studies, and claims that *all* micro structures (organised elements) discovered within meteorites were either artefacts or contaminants led to a general rejection of meteoritic microfossil identifications in the 1960's.

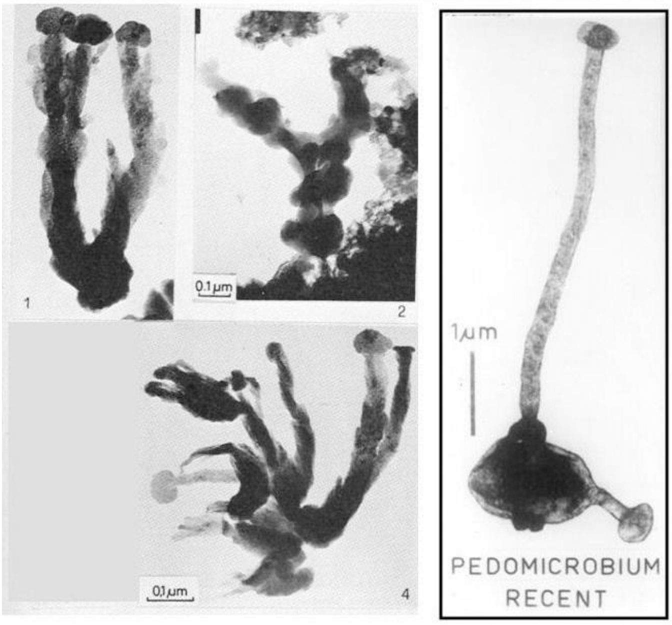

Fig. 8. Microfossils in the Murchison meteorite (left) discovered by H.D.Pflug (1984)compared with a microbial structure in a recent geological deposit (28).

The situation began to change in the 1980's when H.D. Pflug discovered a profusion of microfossils in ultrathin sections prepared from the Murchison meteorite, a carbonaceous chondrite that fell in Australia on 28 September 1969 (24). The contaminant-free experimental method adopted by Pflug appeared to be beyond reproach.

Pflug's discoveries made after we had launched the theory of cometary panspermia, made it now very difficult to reject the fossil identification – but unfortunately they were. The hostility to Pflug's work was spear-headed by those who wished to maintain the orthodox unproven theory of abiogenesis on the Earth. More recent work by Richard Hoover from 2005 to the present day have provided even more striking evidence of the existence of microbial fossils in the Murchison meteorite and in several other carbonaceous meteorites (30). But the response continues to be to ignore this data – with the mantra that "extraordinary claims need extraordinary evidence".

10. The disputed Polonnaruwa meteorite: recent relevant studies

Perhaps one of the most interesting recent developments in this area were related to a meteorite fall in Sri Lanka in 2012 (26). Minutes after a fireball was seen by a large number of people in the skies over Sri Lanka on 29 December 2012, a large bolide evidently disintegrated and fell in the village of Araganwila, which is located a few miles away from the historic ancient city of Polonnaruwa. At the time of entry into the Earth's atmosphere the parent body of this Polonnaruwa "meteorite" would have had most of its interior porous volume filled with water, volatile organics and possibly viable living cells. Pieces of this meteorite were found to very porous, similar to the 162173 Ryugu asteroid (27,28).

Fragments from a freshly cleaved interior surface of the Polonnaruwa meteorite were mounted on aluminum stubs and examined by Jamie Wallis under an environmental scanning electron microscope (26). Images of the sample at low magnification displayed a wide range of structures that were distributed and enmeshed within a fine-grained matrix, examples of which are shown in Fig 9. These include fresh water and seawater diatoms and an extinct microbial fossil (top left) known as an acritarch. These structures were deeply ingrained in the rock matrix and the range of species that were found cannot be reasonably explained on the basis of terrestrial contamination. The space origin of these rocks was challenged on the grounds that they are far too porous for being of asteroidal or cometary origin.

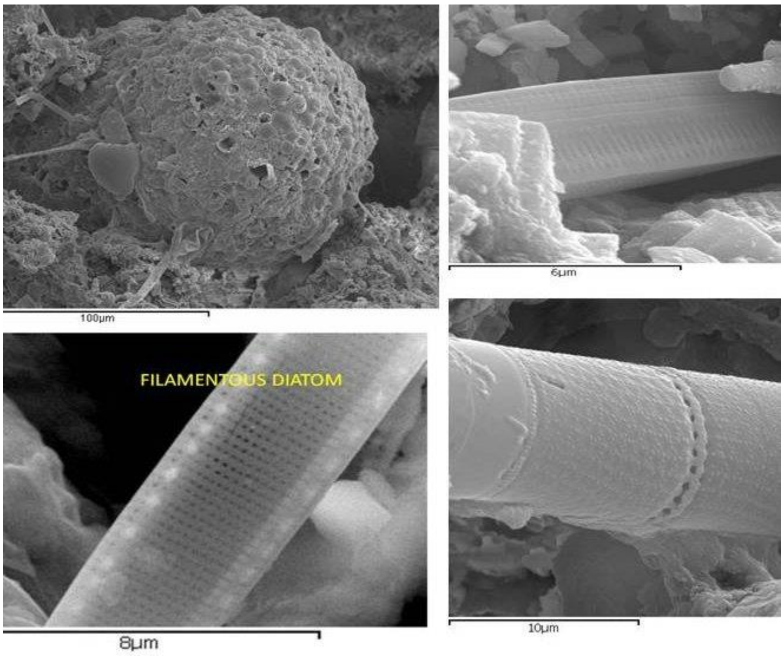

Fig.9 Fossilised acritarch (top left) and diatoms in the Sri Lankan Polonnaruwa meteorite that fell in 2012.

This objection, however, been shown to be false following the discoveries relating to the asteroid 162173 Ryugu that we have already discussed. It should also be recalled that earlier studies of the distribution of stable oxygen isotopes in the Polonnaruwa stones had left little doubt as to their cosmic origin (26). Furthermore, neutron activation studies on the stones carried out by Hoover et al (27) have yielded even more compelling evidence of their likely space origin. From the distribution of heat-producing radioactive elements (Potassium, Thorium, Uranium and the rare earth elements) it has been asserted that the Polonnaruwa stones were consistent with a cometary/asteroidal origin, where a parent body had once contained liquid water domains. Such domains in the parent body of these stones would have served as habitats for microorganisms including diatom species seen in Figs.8 and 9. Since these meteorites cannot be seen as any other than pieces of extinct cometary fragments, the idea of microbial life carried within comets would appear to be vindicated.

10. Stratospheric Sampling

Even more direct proof of ongoing panspermia would be achieved if we can demonstrate beyond doubt that microbial life is still arriving at the Earth. This could be best achieved by sampling the stratosphere which was done under rigorously controlled conditions for the first time in 2001. In collaboration with the Indian Space Research Organisation a group of UK scientists recovered, under strictly aseptic conditions, samples of stratospheric air from 41km from which positive detections of microorganisms were reported (28). The number of bacterial cells collected in a measured volume of the stratosphere at 41km led to an estimate of an in-fall rate over the whole Earth in the range 0.3 to 3 tonnes of microbes per day. This converts to some 20 to 200 million bacteria per square metre arriving from space every single day.

This truly vast number of infalling micro-organisms pales into insignificance when compared to bacteria and viruses normally resident at the Earth's surface, some of which could be occasionally lofted to heights of about 3km in upward air currents and subsequently brought down in mist and rain. The total flux of such bacteria and viruses falling back on the tops of the Sierra Nevada mountains was recently studied by Reche et al (29). The average downward flux of viruses from this height, mainly recycled from the ground, was estimated to be 800 million per square metre per day. If both the space-incident microorganisms and terrestrial microbes are mixed into this estimate their genetic differences could turn out to be difficult to detect. Efforts to do this, however, are clearly of paramount importance, and this should be considered an international scientific priority.

Recently microorganisms were also discovered on the outside of the International Space Station that orbits at 400km above the Earth by Grebennikova, T.V., et al, (30). There is no easy way to maintain that such microorganisms could have been lofted from the surface of the Earth, so strongly supportive evidence for panspermia continues to grow in many directions. More expensive and sophisticated investigations need to be carried out even on the samples collected so far, if we are to prove beyond a shadow of doubt that these microbes are unequivocally alien. The sad truth is that funding for such vitally important experiments is well-nigh impossible to secure due to a deeply ingrained prejudice in favour of an Earth-centred theory of biology.

11. Diseases from Space and Pandemics

Studies of pandemics in history have led to discussions of the possibility of the space origin of viral diseases (12). One important piece of historic evidence that emerged 102 years ago relates to the Influenza pandemic of 1918-1919. Reviewing all the available data relating to this pandemic, Dr. L. Weinstein wrote thus in the New England Journal of Medicine:

"Although person-to-person spread occurred in local areas, the disease appeared on the same day in widely separated parts of the world on the one hand, but on the other, took days to weeks to spread relatively short distances. It was detected in Boston and Bombay on the same day, but took three weeks before it reached New York City, despite the fact that there was considerable travel between the two cities. It was present for the first time at Joliet in the State of Illinois four weeks after it was first detected in Chicago, the distance between those areas being only 38 miles……" (L. Weinstein, *New England Journal of Medicine*, May 1976.)

In the context of an unknown or poorly defined origin of the current Covid-19 pandemic, and with the growing evidence in support of panspermia, a *panspermic* primary origin of this virus cannot be ruled out. Many aspects of the epidemiology of this new virus do indeed support the idea of a primary atmospheric fall-out followed by person-to-person spread; and the disentanglement of the two processes presents a continuing challenge to the world (31, 32).

In the absence of hard evidence that any virus is of Earthly origin, a space origin cannot be ruled out *ab initio*. This is particularly the case since the total viral content of the Earth is truly astronomical and has by no means been fully charted. For example, a single litre of seawater collected in marine surface waters has been estimated to contain more than 100 billion viruses (33). The total viral content of the oceans is estimated to be 10^{30}; the vast majority of identified viruses are informationally rich bacterial phages, but an unknown component of other viruses is also included in this tally. This number is astoundingly super-astronomical and exceeds by more than a factor of a million the total number of stars in the entire observable universe which is ~ 10^{24}. This comparison of astronomically big numbers is a startling indication of a connection between life on Earth and the wider cosmos (see Fig.10).

.

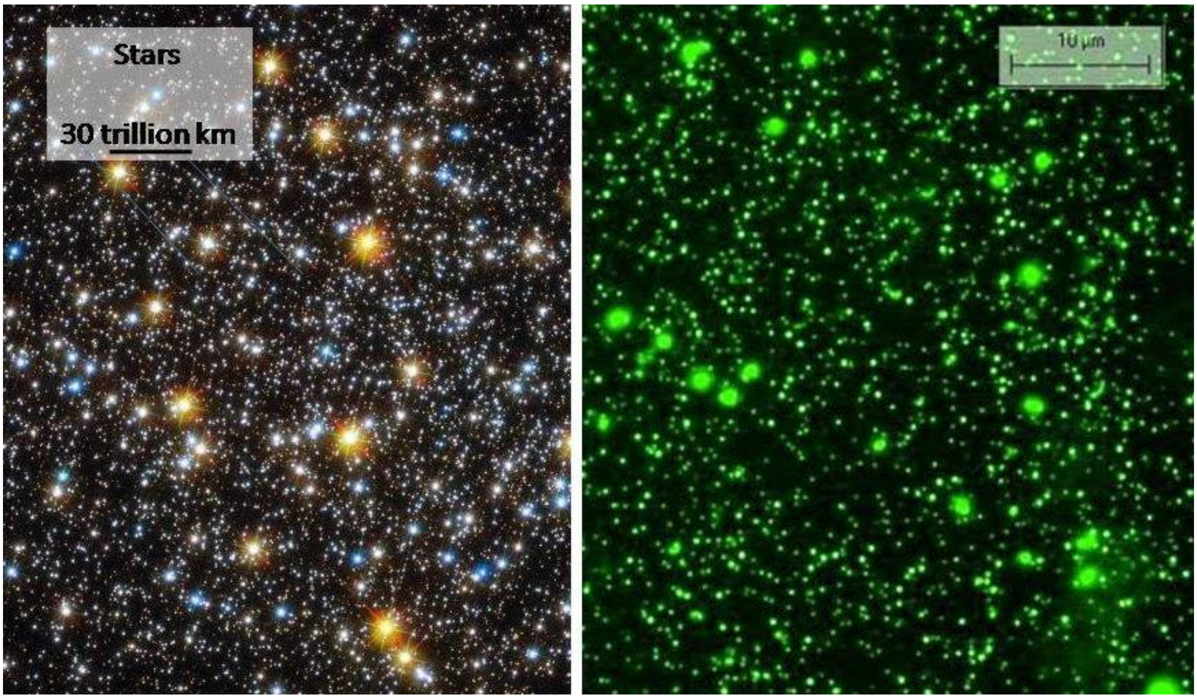

Fig.10 Left: image of a dense region of the Milky way where average distance between foreground bright (nearer) stars is typically a trillion kilometres (Image courtesy of NASA).
Right: Fluorescence image of a drop of ocean water containing over a million individual viruses (DOI: 10.1038/ismej.2011.101)

The footprints of viruses in the genomes of all terrestrial life forms began to be unraveled at the turn of the millennium when whole genomes, including the human genome, came to be sequenced for the first time. One of the many surprises that followed was the discovery that what was once considered “junk DNA” actually had a viral origin. Perhaps as much as 30% of our DNA consists of retroviral sequences (endogenous retroviruses, ERVs) - RNA viruses that have reverse transcribed their RNA into DNA. These are the relics of ancient viruses of cosmic origin that may have actually contributed to our evolution over hundreds of millions of years – and they clearly disprove the criticism that cosmic viruses cannot be the cause of pandemic disease (32).

On the Earth a continued arrival of new bacteria and viruses must have taken place from the time when microbial life was first introduced by comet impacts. New viruses eventually succeed in becoming incorporated into the genomes of evolving lifeforms, this process continuing over billions of years of geological history. Such interaction of new viruses with evolved host species is not always harmonious, however. Throughout recorded history we have clear evidence of a succession of pandemics of disease that have swept over the planet from time to time – the most recent pandemic of COVID-19 being a case in point.

9. Conclusion

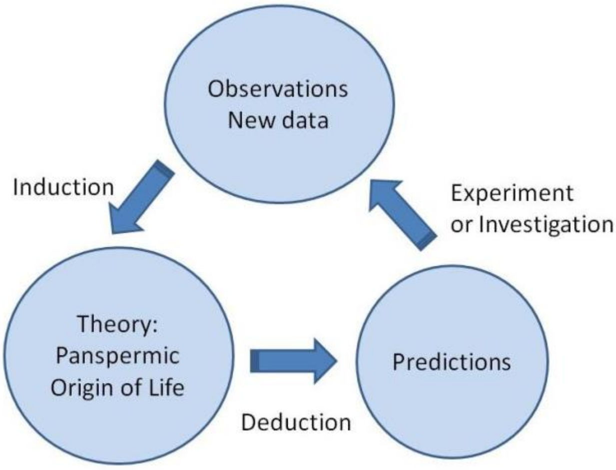

Fig. 11: Falsification/verification feedback loop of scientific methodology

In accordance with well-established conventions of scientific methodology we can use a feedback loop such as depicted in Fig. 11 to generate cycles of prediction – verification/falsification – re-affirmation so as to put any theory or hypothesis such cosmic biology discussed in this article to ever more stringent test. I need hardly reiterate that this process has indeed been used over many years leading to a veritable catalogue of successes and confirmations that imply consistency with the hypothesis of cometary panspermia. This is schematically indicated in Fig.12.

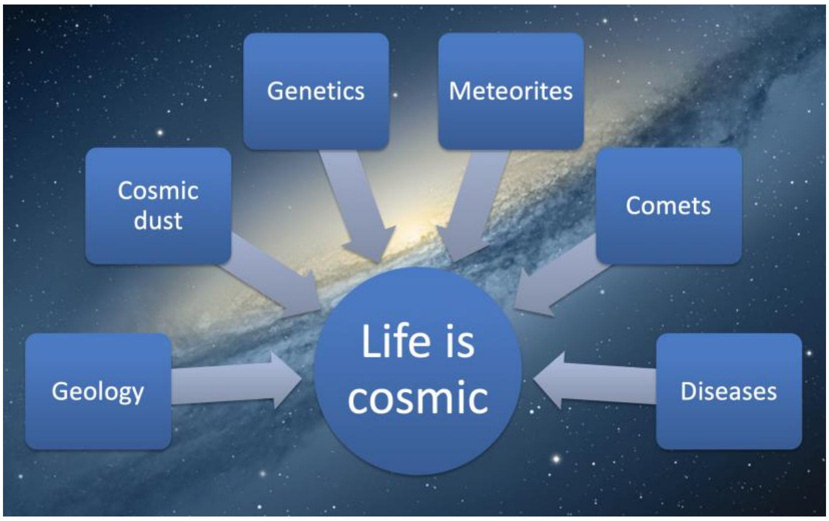

Fig.12 Sources of evidence converging on the theory that life is a cosmic phenomenon.

From a personal viewpoint I find it curious to reflect that the spectroscopic identification of interstellar dust and molecules in space with biochemicals that I started in the 1970s has come into sharp focus in 2022. Their biological relevance once vehemently contested is now widely conceded albeit to a very limited degree. The trend remains to assert, albeit reluctantly, and without any proof, that we may be witnessing the operation of prebiotic chemical evolution on a cosmic scale – a process we have discounted (earlier in this article) as inadmissible on probabilistic grounds.

If biological evolution and replication are regarded as the only secure relevant empirical facts - life always generates new life – and this must be so even on a cosmic scale. Maintaining the premise of an Earth-centred origin of life, which some scientists still prefer to do, harks back to an outdated Aristotelian world view (“fireflies emerging from a mixture of warm earth and morning dew…”) that has held sway for over 2 millennia. We conclude by reminding the reader that a very similar situation prevailed before the Ptolemaic Earth centred solar-system was finally abandoned. The historian of science Thomas Kuhn writes thus:

“ ......The state of Ptolemaic (Earth-centred) astronomy was a scandal before Copernicus' announcement. Given a particular discrepancy, astronomers were invariably able to eliminate it by making some particular adjustment in Ptolemy's system of compounded circles. But as time went on, a man looking at the net result of the normal research effort of many astronomers could observe that astronomy's complexity was increasing far more rapidly than its accuracy and that a discrepancy corrected in one place was likely to show up in another…”

Let us hope this will not be the case for the overwhelming evidence of cosmic biology in the year 2022 and that cultural obstacles to accepting the facts will be overcome (34). Conceding a long overdue paradigm shift from Earth-centric biology to Cosmic life would have far-reaching implications that go beyond science. With a radical revision of our place within the cosmos and our self-acclaimed supremacy as humans will change beyond all recognition. This could be the only route to a sustainable future where humans learn at last to live in peace amongst themselves and in harmony with the wider natural environment.

References

1. Hoyle, F. and Wickramasinghe, N.C., 1978. Lifecloud, J.M.Dent & Sons, Lond.

2. Hoyle, F. and Wickramasinghe, N.C., 1982a. In: C. Ponnamperuma, ed. Comets and the Origin of Life. Dordrecht: D. Reidel, 227.

3. Hoyle., F. and Wickramasinghe, N.C., 1985. Living Comets (Univ.Coll.Cardiff Press)

4. Hoyle, F. and Wickramasinghe, N.C., 1986. The case for life as a cosmic phenomenon, Nature, 322, 509

5. Hoyle, F. and Wickramasinghe, N.C., 2000. *Astronomical Origins of Life: Steps towards Panspermia*, Kluwer, Dordrecht

6. Burbidge, E.M., Burbidge, G.R., Fowler, W.A. and Hoyle, F., 1957 Synthesis of the elements in stars, Rev.Mod.Phys., 29(4), 547

7. Wickramasinghe, C., 2010.The astrobiological case for our cosmic ancestry *International Journal of Astrobiology* **9** (2) : 119–129

8. Wickramasinghe, C. (ed.), 2015. Vindication of Cosmic Biology, World Scientific Press, Singapore

9. Hoyle, F. and Wickramasinghe, N.C., 1976. Primitive grain clumps and organic compounds in carbonaceous chondrites, Nature 264, 45-46

10. Hoyle, F. and Wickramasinghe, N.C., 1977. Identification of the 2200A interstellar absorption feature, Nature, 270, 323-324

11. Hoyle, F. and Wickramasinghe, N.C., 1978. Calculations of infrared fluxes from galactic sources for a polysaccharide model, *Astrophys.Sp.Sci*., 53, 489- 505

12. Hoyle, F. and Wickramasinghe, N.C., 1979. *Diseases from Space*, J.M. Dent & Sons, London.

13. Hoyle, F. and Wickramasinghe, N.C., 1982. Evolution from Space, J.M.Dent & Sons, Lond.

14. Mayor, M. and Queloz, D., 1995) A Jupiter-Mass Companion to a Solar-Type Star, *Nature,* 378, 355-359. http://dx.doi.org/10.1038/378355a0

15. Kopparapu, R. K. 2013. A revised estimate of the occurrence rate of terrestrial planets in the habitable zones around Kepler M-dwarfs, Astrophys.J., 767, L8

16. Slijepcevic, P. and Wickramasinghe, C., 2021, Reconfiguring SETI in the microbial context: Panspermia as a solution to Fermi's paradox, BioSystems 206 (2021) 104441

17. Capaccione, F., Coradini, A., and Filacchione, G., 2015. The organic-rich surface of comet 67P/Churyumov-Gerasimenko as seen by VIRTIS/Rosetta. *Science* 347 (6220).

18. Wickramasinghe, N.C., Hoyle, F. and Lloyd D., 1996. Eruption of comet Hale-Bopp at 6.5AU, Astrophys.Sp.Sci., 240, 161

19. Biver, N. *et al.*, 2015. Ethyl alcohol and sugar in comet C/2014Q2 (Lovejoy) Sci.Adv.1:e1500863 23 October, 2015

20. Wickramasinghe, N.C., 2022. Giant Comet C/2014 UN271 (Bernadinelli-Bernstein) provides new evidence for cometary panspermia, Int. J. Astron.Astrophys, 12, 1-6

21. Bell, E.A., Boehnke, P., Harrison, T. *et al.*, 2015. Potentially biogenic carbon preserved in a 4.1 billion-year-old zircon, PNAS, 112 (47) 14518-14521
www.pnas.org/cgi/doi/10.1073/pnas.1517557112

22. Wallis, M.K. and Wickramasinghe, N.C. 2004. *Mon.Not. Roy.Astr.Soc.*, **348**, 52

23. Claus, G., Nagy, B. and Europa, D.L., 1963. Ann. NY Acad. Sci., 108, 580.
DOI: 10.1016/bs.adgen.2020.03.003

24. Pflug, H.D., 1984. *In:* N.C. Wickramasinghe, ed. *Fundamental Studies and the Future of Science*, Cardiff: Univ. College Cardiff Press.

25. Hoover, R. B., 2005, *In*: R.B. Hoover, A.Y. Rozanov and R.R. Paepe, eds. *Perspectives in Astrobiology. Amsterdam*: IOS Press, **366**, 43.

26. Wallis, J., Wickramasinghe, N.C., Wallis, D.H. et al, 2013. Physical, chemical and mineral properties of the Polonnaruwa stones, Proc SPIE, 8865-08: 1-24

27. Hoover, R.B., Frontasyeva M., Pavlov S., 2020. Epithermal Neutron Activation Analysis of Carbonaceous Chondrites and the Polonnaruwa/Aralaganwila Stones. Aspects Min Miner Sci. 6(1). AMMS. 000626. (DOI: 10.31031/AMMS.2020.06.000626)

28. Harris, M. J., Wickramasinghe, N.C., Lloyd, D. et al., 2002.
Detection of living cells in stratospheric samples. *Proc. SPIE*. 4495, 192–198.
doi: 10.1117/12.454758

27. Kitazato, K., Miliken, R.E. and Tsuda, Y., 2021. Thermally altered subsurface material of asteroid(162173) Ryugu, Nature Astronomy https://doi.org/10.1038/s41550-020-01271-2

28. Le Roy L., Bardyn, A., Briois, C. et al, 2015. COSIMA calibration for the detection and characterization of the cometary solid organic matter, Planetary and Space Sci., 105, 1-25

29. Reche, I., D'Orta, G., Mladenov, N. *et al.*, 2018. Deposition rates of viruses and bacteria above the atmospheric boundary layer, The ISME Journal, (https://doi.org/10.1038/s41396-017-0042-4)

30. Grebennikova, T.V., Syroeshkin, A.V., Shubralova, E.V. et al, 2018. The DNA of bacteria of the World Ocean and the Earth in cosmic dust at the International Space Station, The Scientific World Journal, Article ID 7360147. https://doi.org/10.1155/2018/7360147

31. Steele, E.J., Gorczynski, R.M., Lindley, R.A. et al, 2021. Cometary origin of Covid-19, J. Infectious Disease and Therapeutics, 2:1-4

32. Wickramasinghe, N.C., Steele, E.J., Wallis, D.H. et al, 2021. Footprints of past pandemics in the human genome, Virol.Curr.Res., 5:4

33. Furnham, J.A., 1999. Marine viruses and their biogeochemical and ecological effects. Nature, 399(6736):541-8.

34. Wickramasinghe, C., 2022. Panspermia versus Abiogenesis: a clash of cultures, J. Scientific Exploration, 36(1), 121