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Review Article

Cultural Obstacles to the Acceptance of Life as a Cosmic Phenomenon

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ABSTRACT

We are led to believe that modern science is free of all forms of irrational prejudice that had plagued science over the centuries. It is argued that this is not true in relation to the most fundamental aspects of biology, including the question of the origin of life and its cosmic provenance. From the early 1980's evidence in favor of the theory of cosmic life and a version of panspermia that was developed by Fred Hoyle and the present author has grown to the point that its continued marginalisation or even outright rejection is a cause for serious concern. The cultural impediments to a proper assessment of these crucially important ideas should be recognized and overcome in the interests of science as well as of humanity.

Keywords: Panspermia; Cosmic origins of life; Sociology of science.

INTRODUCTION

From the time of the earliest philosophies of classical Greece the perennial struggle has been to disentangle religion and the "gods" from their involvement in explanations of the external world. Democritus (460-370 BCE) and Epicurus (341-270 BCE) held firmly to rationalist explanations including the concept of an infinite and eternal universe. They had both supposed that all matter is comprised of invisible particles (atoms) and that all phenomena in the natural world–including life are the result of such atoms moving, swerving, and interacting with each other in empty space in natural and predictable ways. Nothing important was left to mystery or the gods. Although most of Epicurus' writings have not survived into the modern age, a long succession of his disciples have fortunately recorded and transmitted his views, particularly Metrodorus (331-277 BCE), and much later the poet Lucretius (99-55 BCE). The surviving writings of these authors bear testimony to a profoundly post-modern Epicurian view of life in the cosmos. At around 400 BC Metrodorus of Chios wrote thus

"It is unnatural in a large field to have only one shaft of wheat and in the infinite universe only one living world....." (Metrodorus). "Nothing in the universe is unique and alone, and therefore in other regions there must be other Earths inhabited by different tribes of men and breeds of beasts....." (Lucretius). Such an evidently postmodern set of ideas relating to life implied also a Universe that was essentially independent of control by any god or pantheon of gods.

The same freedom from theistic control was implied in pre-Socratic ideas relating to the origins of life first attributed to the philosopher Anaxagoras of Clazomenae (500 to 428 BCE). Anaxoragas posited that 'seeds' (sperma) are distributed everywhere (pan) throughout the cosmos - ***pan*** linked with ***sperma*** signifying seeds of life everywhere and thus defining the etymology of the modern word panspermia. We should note, however, there are much earlier references to the same basic idea in the wider world outside of Europe. Ancient Egyptian papyri and engravings have references and depictions of panspermia that date before the second millennium BC; and even older Vedic traditions of ancient India encapsulate ideas concerning the cosmic nature, antiquity and eternity of life [1]. Vedic ideas on the antiquity and ubiquity of life found their way into Jain as well as Buddhist philosophy, as for example in this quote from a Buddhist text:

"As far as these suns and moons revolve, shedding their light in space, so far extends the thousand fold world system. In it there are a thousand suns, a thousand moons, a thousand inhabited Earths and a thousand heavenly bodies. This is called the thousand fold minor world system...." (*Anguttara Sutta*, c.1st century BCE).

The non-European provenance of the concept of panspermia, in the author's view, played no minor role in the development of the later prejudice against it. If this sounds strange, we need only to recall the initial European resistance to the adoption of decimal number system that we now use everywhere, and on which the whole

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edifice of modern mathematics and modern science depends. This number system was firmly rejected throughout Europe for centuries in favor of the bizarrely inconvenient Roman numerals, and it was not until the 16th century CE that the Hindu numerals (renamed Hindu-Arabic numerals) replaced the old Roman numeral system [2]. The delay in the transition was undoubtedly connected with a deep-rooted suspicion of an alien non-Christian pagan culture from which this number system had emanated.

RESISTANCE TO PANSPERMIA

The concept of panspermia has also had a chequered history. The first rejection of panspermia came scarcely a century after it was first proposed by Anaxoragas and Epicurus. This was mainly due to the powerful influence of Aristotle (385-323 BCE). Aristotle proposed in its place the concept of the "spontaneous generation" of life, suggesting that life arose spontaneously from non-living matter whenever and wherever the right conditions prevailed. This was famously exemplified by his "observation" of "fireflies emerging from a mixture of warm earth and morning dew." Although religion or theistic intervention was not explicitly stated by Aristotle, the doctrine of spontaneous generation of life on the Earth lent itself readily to such an interpretation. Aristotle's stature as a philosopher and observer of the natural world is clearly evident in a vast number of surviving texts and commentaries. Beyond the idea of spontaneous generation, Aristotle's writings span an incredibly wide range of disciplines including logic, metaphysics, biology, psychology, ethics, political theory, aesthetics and rhetoric.

Following the adoption of Christianity in the Roman Empire by Emperor Constantine in the 3rd century CE it came as no surprise that Aristotelean philosophy had to be somehow accommodated within theological doctrine. This was accompanied by a firm rejection of the ideas of Anaxoragas, Democritus and Epicurus, ideas that were thought to be essentially atheistic.

The Aristotelean worldview later came to be fine-tuned by Christian philosophers, notably Thomas Aquinas (1224–1274 CE), who advocated a strictly geocentric model of the world, one that necessarily included the concept of life also being Earth-centered. Allegiance to such a model soon came to be tied up with faith rather than fact, so overturning it became ever more difficult as the centuries progressed. The concept of a physical universe firmly centred on the Earth persisted for several centuries and was of course eventually dismantled by the Copernican revolution of the 16th century, though not without a struggle involving the interventions of Galileo, Kepler and Newton spanning period of some 150 years. The idea of earth-centred life and biology, however, persisted right through into modern times. This comparison is summarised in (Figure 1).

ABIOGENESIS *VS.* PANSPERMIA

Aristotelean doctrine of spontaneous generation ultimately took the modern form of abiogenesis. At the dawn of the 20th century the logical choices in relation to the beginnings of life lay between two competing concepts: (a) Abiogenesis life generated *in situ* on earth and with such life emerging and evolving independently of the wider cosmos, and (b) Panspermia life being a cosmic phenomenon, arriving on a planet such as Earth and evolving by means of the continued transfer and interchange of microbiota (bacteria and viruses) in a vast cosmic context. As we have already mentioned the latter point of view has deep historic roots going back to pre-Socratic philosophers, and perhaps even much earlier.

Figure 1: The trajectory of the first Copernican revolution (above), compared to the progress of Panspermia–the second Copernican revolution (below)

It is interesting to note that throughout the past 500 years, panspermia has received only scant mention in scientific or literary sources in Europe. In the early 18th century the French historian Benoît de Maillet (1656-1738) wrote that the cosmos "is full of seeds of everything that can live in the universe" which is of course reminiscent of the original ideas of Epicurus and Anaxagoras [3]. However, any serious reference to panspermia as a scientific proposition, let alone support for it, does not show up until the latter part of the nineteenth century.

Louis Pasteur (1822-1895) was the first to confront the subject of panspermia with a series of famous experiments–e.g: the souring of milk and the fermentation of wine. He showed to everyone's satisfaction that these processes do not take place in the absence of microorganisms, and therefore that microorganisms in general must always be derived from pre-existing microorganisms [4]. Pasteur thus effectively disproved the long reigning dogma of "spontaneous generation", the idea that that life could arise spontaneously from inorganic matter. He also famously enunciated the dictum *Omne vivum e vivo*—all life is from life, and this view was enthusiastically supported by several distinguished contemporary physicists at the time. For instance, the German physicist Hermann von Helmholtz [5] wrote:

"It appears to me to be fully correct scientific procedure, if all our attempts fail to cause the production of organisms from non-living matter, to raise the question whether life has ever arisen, whether it is not as old as matter itself, and whether seeds have not been

carried from one planet to another and developed everywhere where they have fallen on fertile soil..." and in Britain, Lord Kelvin (William Thomson) [6] declared:

"Dead matter cannot become living without coming under the influence of matter previously alive. This seems to me as sure a teaching of science as the law of gravitation.....".

In Sweden the Nobel prize winning chemist Svante Arrhenius was similarly swayed and enthusiastically proselytised the "doctrine of panspermia" in his book *Worlds in the Making* [7].

In retrospect it is difficult to believe that all such pronouncements were consistently and stridently ignored in the decades that followed. At every turn the Earth-centered Aristotelian point of view of spontaneous generation reared its head to dominate even the strongest evidence pointing to the validity of an alternative panspermic viewpoint. Weak and uncertain evidence of the lack of space-hardiness of bacteria was presented in the 1920's to argue stridently against the feasibility of panspermia. Over the past few decades, however, the space hardiness of bacteria has been established almost beyond refute, so all the initial objections that were raised are shown to be false. However, in the late 1970's when Hoyle and the present author found it prudent to revisit Panspermia, it was already considered to be an idea that had been long since been abandoned, proved as invalid and cast into a dust bin of wrong ideas. Combatting this prejudice has been a long and continuing struggle.

STEPS TOWARDS RESTORING PANSPERMIA AND THE THEORY OF COSMIC LIFE

The earliest beginnings of the Hoyle-Wickramasinghe theory of panspermia and cosmic life have been clearly recorded in a series of publications in high profile journals during 1974-1977. Our first paper in the series appeared in the journal *Nature* arguing for organic polymers in the form of polyoxymethylene distributed throughout interstellar space [8]. This was followed by a long sequence of publications in which we explored various abiotic processes by which the evolution of interstellar molecules into prebiotic structures may possibly have taken place [9-11]. In 1975 Vanysek and the present author [12] first proposed the existence of organic polymers in comets, thus challenging the hallowed Whipple dirty snowball theory of comets [13].

Organic structures related to polyoxymethylene polymers have now been identified in comet 67P/C-G, but the modern discoverers have not thought it necessary to reference or acknowledge our earlier discussions [14].

Historically, we next discussed mechanisms by which the relatively simple organic molecules could come to be assembled into biologically relevant molecular structures. In one such attempt we discussed the development of molecular complexity that may have occurred within clumps of loosely adhered interstellar organic polymers. We also discussed the possibility of chains of sugar molecules–cellulose and polysaccharides forming in molecular outflows from stars. Arguing further that comets, which condensed in the outer regions of the solar system, mopped up prebiotic molecules from interstellar space, we wrote thus in 1978.

"For the origin of life on our planet, therefore, all that was needed was a primitive atmosphere which allowed the soft landing of small cometary bodies carrying interstellar prebiotic molecules. We know that such soft landings of meteorites occur today. In the beginning the solar system would have picked up considerable quantities of cometary-type debris from the parent cloud as it carried out an oscillatory movement within the cloud. So interstellar prebiotics, delivered by comets to Earth to make up the canonical primordial soup,was the position we had arrived at in 1978. At the time such a position was considered to be radical, outrageously contentious, and even heretical. It is ironical that precisely the same position is now being adopted by conventional science (and reported in the popular media) seemingly oblivious of its earlier precedents. But the further logical development of our ideas began at this stage to take a more radical turn from cosmic prebiology to cosmic life itself–life originating on a cosmological scale and being distributed throughout galaxies as bacteria and viruses mainly carried by comets.

REVIVAL OF PANSPERMIA AND LIFE AS A COSMIC PHENOMENON

In the development of our own thinking beyond 1978 it was a failure to understand how the exceedingly specific arrangements of monomers–such as amino acids–build up into long chain polymers as in enzymes, or nucleotide bases in DNA, with a superastronomical information content that led us to challenge the holiest of holy grails in biology. This insuperable difficulty with the theory of abiogenesis in an Earth-bound primordial soup remained even if, as we had earlier proposed, the simpler organic units came from space [15-17].

The alternative scenario that we began to explore was that life at a microbial and genetic level is a truly cosmic phenomenon originating on a cosmological scale that far transcends the scale of planets or even individual galaxies. Comets, in this scheme, contain not just the chemical building blocks of life but fully-fledged bacterial life as well as viruses and viroids and they serve as the incubators and transporters of cosmic life. In such a picture complex organic molecules that were recently detected in comets as well as in interstellar space are mostly the result of the break-down of biological cells and complex biological structures, a process that would inevitably occur in the course of the various processes that lead to the transport of microorganisms between different galactic habitats. Contrary to what is often wrongly stated, in popular as well as more scientific writings, panspermia is now furthest removed from mere speculation; rather it has become firmly rooted in data and irrefutable facts

Spontaneous generation or panspermia?–this is fundamentally a cultural choice at the outset, but once the choice is made it could be rigorously subjected to empirical tests and verification/falsification in a Popperian sense. This is precisely what was carried out and recorded in several hundred technical publications spanning nearly four decades.

GROWING EVIDENCE FOR COMETARY PANSPERMIA

From the 1980's onwards the present author, in collaboration first with the late Sir Fred Hoyle, and subsequently with many other collaborators, began to assemble a vast body of data and evidence that supports panspermia from astronomy, geology as well as biology. New data and facts continued to provide ample verification of a long sequence 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. Thus, life as a cosmic phenomenon was thereafter no longer to be considered a mere speculation or hypothesis but a theory that has satisfied every test that has thus

far been applied.

All this was first documented and discussed in an extended essay by Hoyle and the present author and published as the first memoir of the institute of Fundamental Studies in Sri Lanka following a presentation at an international conference held there in December 1982 [18].

This historic conference was attended by a large number of international scientists including amongst them Cyril Ponnamperuma, a proponent of abiogenesis as well as Hans D. Pflug who was among the first scientists to discover definite evidence of microfossils in carbonaceous meteorites (Figure 2). The proceedings of this conference were later published in a book entitled "Fundamental Studies and the Future of Science" [19]. The case in support of the idea of life as a cosmic phenomenon has grown steadily from 1982 to the present time.

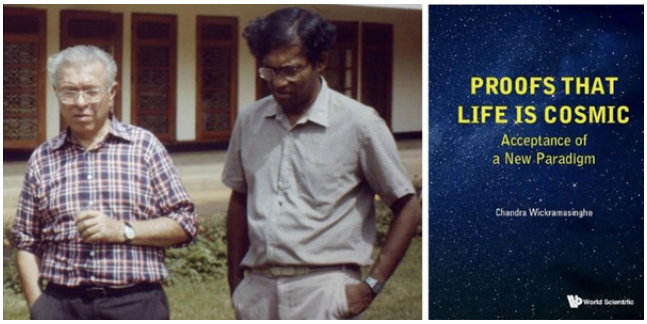


Figure 2: Fred Hoyle and the author in Sri Lanka in 1982 where the original version of an extended article with the title "Proof that Life is Cosmic–by Prof. Sir Fred Hoyle and Prof. Chandra Wickramasinghe" was published as a Memoir of the Institute of Fundamental Studies, Sri Lanka, and recently reprinted with an extended introduction

STATUS IN 1986

The first paper bearing the title "The case for life as a cosmic phenomenon–Hoyle et al." was published in Nature [20]. This paper was written following the verified prior predictions from this theory of specific astronomical facts upto 1986–first the infrared spectrum of the galactic centre source GC-IRS7 and then of the dust from comet Halley (Figure 3).


NATURE VOL. 322 7 AUGUST 1986 — COMMENTARY — 509

The case for life as a cosmic phenomenon

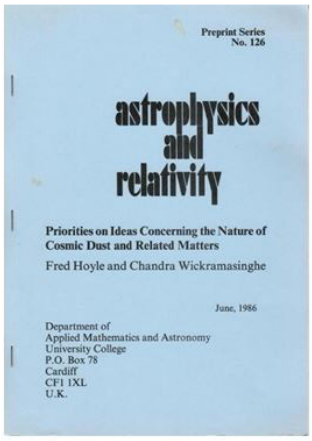
from F. Hoyle and N.C. Wickramasinghe

The arguments in support of life as a cosmic phenomenon are not readily accepted by a culture in which a geocentric theory of biology is seen as the norm.

Figure 3: The case for life as a cosmic phenomenon.

In the run-up to the publication of this paper in Nature over 50 communications were already published in the same journal, essentially tracing the story of the birth of astrobiology. After we shifted our emphasis from cosmic pre-biology to cosmic biology including the revival of panspermia many journals including *Nature* promptly stopped publishing such contributions and we turned first to the D. Reidel journal astrophysics and space science followed later by a series of other journals including the international journal of astrobiology, whose editors saw fit to continue publishing this unfolding story. It became evident that the journal refereeing system, which should have served only to check technical errors inconsistency.

Began to serve as a powerful screen of censorship. In the 1980's before the arrival of the internet Fred Hoyle and the present author also devised a preprint system (Cardiff blue preprint series) that was funded by Mr. Garry Weston, CEO of Associated Foods Plc. This was called by critics a "Samizdat system" akin to the system used by Soviet Russia to distribute censored publications that were unpalatable to the authorities. An example of the cover of this infamous "blue preprint" series is shown in (Figure 4).


Preprint Series
No. 126

astrophysics and relativity

Priorities on Ideas Concerning the Nature of Cosmic Dust and Related Matters

Fred Hoyle and Chandra Wickramasinghe

June, 1986

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Applied Mathematics and Astronomy
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Figure 4: Cover of a blue Cardiff preprint.

STATUS IN 2001

At the start of the new millennium Fred Hoyle and the author succeeded in linking up with the Indian Space Research Organisation (ISRO) to make the first carefully controlled recovery of space-incident microbial structures (bacteria and putative viruses) from a height of 41 km in the stratosphere (Figure 5). The results were published in our joint paper with the title "The detection of living cells in stratospheric samples" and which was first presented in 2001 at a conference in the USA [21]. The photographed abstract of this paper, which was the last paper to be co-authored by Fred Hoyle (he died in August 2001), is reproduced below:


Invited Paper

The detection of living cells in stratospheric samples

Melanie J. Harris[a], N.C. Wickramasinghe[a], David Lloyd[b], J.V. Narlikar[c], P. Rajaratnam[d], Michael P. Turner[b], S. Al-Mufti[a], Max K. Wallis[a], S. Ramadurai[e] & F. Hoyle[a]

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ABSTRACT

Air samples collected aseptically over tropical India at various stratospheric altitudes ranging from 20 to 41 km using cryosampler assemblies carried on balloons flown from Hyderabad have shown evidence of living microbial cells. Unambiguous evidence of living cells came from examining micropore filters on which the samples were recovered with the use of voltage sensitive lipophilic dyes that could detect the presence of active cells. Clumps of viable cells were found at all altitudes using this technique, and this conclusion was found to be consistent with images obtained from electron microscopy. Since the 41 km sample was collected well above the local tropopause, a *prima facie* case for a space incidence of these microorganisms is established. Further work on culturing, PCR analysis and isotopic analysis is in progress.

2001: ISRO balloon flight - Air from 41 km collected in sterile cylinders found to contain an abundance of bacteria that could not have come from the ground

Clump of putative cocci + bacillus

Viable but non-culturable microorganism shown by fluorescent dyes

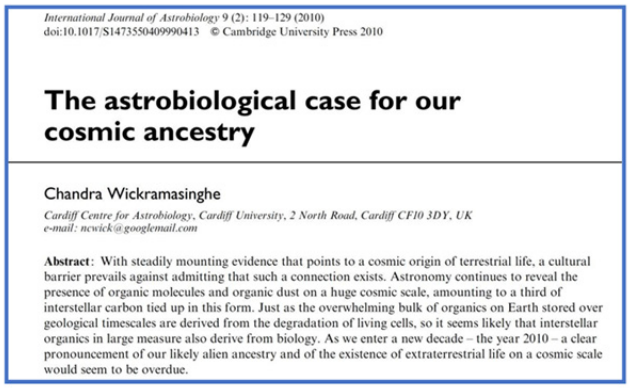
Figure 5: The first detection of microorganisms of putative space origin in the stratosphere, recovered from.

The startling conclusion from this sampling experiment was that positive detections of falling in microbiota collected in a measured volume of the stratosphere at 41 km led to an estimate of an in-fall rate over the whole earth of 0.3-3 tonnes of microbes per day. This converts to some 20-200 million bacteria per square metre

arriving from space every single day. The possible consequence was that pathogenic bacteria and viruses could on occasion be part of this space cargo, and we began to urge a continual surveillance of the stratosphere with a view to dealing effectively with future pandemics. Predictably this advice was ignored for the reason that any ideas connected with life from space and cosmic biology were essentially taboo.

STATUS IN 2010

The decade 2000-2010 continued to be highly productive in leading to a swathe of further verifications of the theory of cosmic life. But it was also traumatic in regard to the growing hostility that had developed. One of the world's first University centres of astrobiology started by Fred Hoyle and myself in Cardiff was closed down by *force majeure* ostensibly on the grounds that the research being carried out failed to attract funding from governmental sources. Notwithstanding these setbacks an ever-increasing string of publications continued to support a variety of aspects of the theory of cosmic life. These publications included significant contributions from Wainwright, Wallis, Napier, Coulson and Wickramasinghe, all of whom were initially linked to the now extinct Cardiff centre for astrobiology [22-26]. At the end of this decade the mantle of the former Cardiff centre with a similar honorary staff complement was taken on as part of a virtual centre for astrobiology by the University of Buckingham in the UK (Figure 6). A similar virtual Centre for Astrobiology was also later set up in Sri Lanka at the University of Ruhuna [27]. At the end of the decade a review of progress towards panspermia was published in the *International Journal of Astrobiology* 9(2):119-129 (2010).



International Journal of Astrobiology 9 (2): 119–129 (2010)
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The astrobiological case for our cosmic ancestry

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Abstract: With steadily mounting evidence that points to a cosmic origin of terrestrial life, a cultural barrier prevails against admitting that such a connection exists. Astronomy continues to reveal the presence of organic molecules and organic dust on a huge cosmic scale, amounting to a third of interstellar carbon tied up in this form. Just as the overwhelming bulk of organics on Earth stored over geological timescales are derived from the degradation of living cells, so it seems likely that interstellar organics in large measure also derive from biology. As we enter a new decade – the year 2010 – a clear pronouncement of our likely alien ancestry and of the existence of extraterrestrial life on a cosmic scale would seem to be overdue.

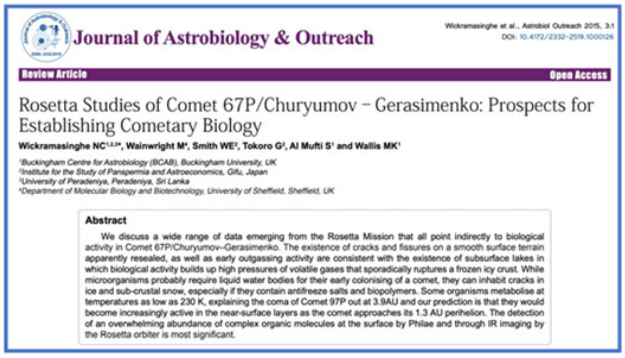
Figure 6: The astrobiological case for our cosmic ancestry

CURRENT STATUS OF THE THEORY OF COSMIC LIFE

From 2010 to the present-day evidence in support of the theory of cosmic life and panspermia has continued to grow at a steady pace, all of which is fully documented in long series of published contributions [28-30]. The continuing research progress was facilitated by the generous support of several private benefactors a The advances made in this period include verifications of a numbe r of explicit prior predictions, for instance the discovery of unmista kable "viral footprints" in our own DNA and the DNA of plants a and animals, showing that cosmic viruses drive biological evolution on the Earth [31].

Amongst the other notable verifications of the panspermia model include the following:

• 2013: On 29 December 2012 a witnessed fireball event in central Sri Lanka led to the collection of highly porous carbonaceous meteorites (Polonnaruwa stones) that were analysed by Wallis et al., with results that were announced first at a conference in the US [32]. A hitherto unknown class of meteorite clearly revealed the presence of microbial fossils including diatoms. Moreover, oxygen isotope studies of the stones revealed oxygen isotope data that confirmed their space origin. Meteoriticists have thus far distanced themselves from this discovery stating that the porosity of the stones made them unlikely to be meteorites (Figure 7). Since then, however, ample evidence for the occurrence of similar asteroidal material has been found (eg the Rygu asteroid), but the Polonnaruwa meteorite data is still being largely ignored. One racist comment by an American meteorite hunter has been recorded that the rural population of Sri Lanka would not be able to distinguish cow dung from meteorites!



Journal of Astrobiology & Outreach

Review Article — Open Access

Rosetta Studies of Comet 67P/Churyumov – Gerasimenko: Prospects for Establishing Cometary Biology

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Abstract

We discuss a wide range of data emerging from the Rosetta Mission that all point indirectly to biological activity in Comet 67P/Churyumov–Gerasimenko. The existence of cracks and fissures on a smooth surface terrain apparently resealed, as well as early outgassing activity are consistent with the existence of subsurface lakes in which biological activity builds up high pressures of volatile gases that sporadically ruptures a frozen icy crust. While microorganisms probably require liquid water bodies for their early colonising of a comet, they can inhabit cracks in ice and sub-crustal snow, especially if they contain antifreeze salts and biopolymers. Some organisms metabolise at temperatures as low as 230 K, explaining the coma of Comet 97P out at 3.9AU and our prediction is that they would become increasingly active in the near-surface layers as the comet approaches its 1.3 AU perihelion. The detection of an overwhelming abundance of complex organic molecules at the surface by Philae and through IR imaging by the Rosetta orbiter is most significant.

Figure 7: Rosetta studies of comet 67P/churyumov-gerasimenko: Prospects for Establishingcometry biology

• 2015: Rosetta studies of comet 67P/Churyumov–Gerasimenko showing consistency with the presence of bacteria.

• 2016: Earliest evidence of life on the Earth discovered during the Hadean epoch 4.2 billion years ago.

• 2018: Steele et al. [33] reviewed all the evidence for panspermia to date and concluded that there is a compelling argument for cosmic viruses driving the evolution of life on the Earth. Evidence from the sudden diversification of species during the Cambrian event cannot be reasonably be explained in any other way.

• 2018-20: Microorganisms found on the outside of the International Space Station 400 km above the Earth confirming the ISRO and other balloon detections in the stratosphere. There is no easy way to maintain that microorganisms discovered on the ISS exterior orbiting at 400 km could have been lofted from the surface of the Earth; thus strongly supportive evidence for panspermia continues to grow unabated.

• 1976-2020: Cosmic viruses and pandemics: If, as we have argued over many years, a cometary impact or impacts led to the first importation of cosmic life to the Earth 4.2 billion years ago, it is reasonable to suppose that subsequent arrivals of cometary material carry biological material that would affect the evolution of terrestrial biology [34]. Evidence for the occurrence of viral footprints (ERVs, HERVs) in the DNA of primates appear to confirm that the development of distinct primate lineages involved with the introduction of viruses which led to devastating pandemics. The discovery of new bacteria and viruses arriving in the stratosphere [35,36] leads to the possibility of some viral pandemics (e.g. influenza and even Covid-19) being driven from space, rather than being of terrestrial zoonotic origin. This aspect of panspermia has been discussed extensively elsewhere [37,38] and will not be further developed in the present article, except to say that viral diseases coming through air and mist is part of medical

tradition throughout the Indian subcontinent. A similar idea of a miasma causing influenza pandemics was in currency in Europe until a viral cause was established but shortly thereafter it came to be ridiculed in the Western medical tradition [39,40]. Course of, the viral aetiology of influenza and or other respiratory viruses does not preclude their arrival in mist and ultimately from space. In this context we have repeatedly urged the institution of a stratospheric surveillance project to monitor the upper stratosphere for detecting incoming potentially harmful pathogens before they reached ground.

• 2021: SETI: Another aspect of panspermia that Predrag Slipjevic and the present writer have highlighted is the role of panspermia in the transmission of complex "intelligent" signals around the Universe, thus impacting on future prospects of SETI programmes.

The partial list of unbroken "successes" given above can be considerably enlarged to include more detailed facets of correspondences between predictions of the panspermia-cosmic life model with an exceedingly diverse set of observations. It would be fair to re-iterate that no wrong theory can be characterised by such an impressive record of the most detailed predictions all being unfailingly verified. The continuing resistance to acknowledging the reality of this extensive set of data clearly needs to be explained.

THE INTERVENTION OF CULTURAL CONSTRAINTS AND DECOLONISATION OF SCIENCE

When one reviews all the supportive evidence set out in section 5, it would appear all the more remarkable that the stronger the supportive evidence for panspermia and cosmic life became, the ferocity and irrationality of opposition to it also grew stronger. The antagonism was possibly aggravated by the fact that all attempts to demonstrate the validity of bound Earth abiogenesis (spontaneous origin of life) in the most advanced laboratories of the world have consistently led to negative results [41,42]. Thus, logically there seemed no other option but to concede "defeat" of the reigning Earth-bound central paradigm of biology and admit.
That panspermia's star is rapidly on the ascendent. Why this that has not yet happened is an important question that needs to be answered. It is becoming amply clear that cultural constraints.
Are playing a crucial role in the stalling of a long overdue paradigm shift in science.

The triumphs of panspermia over rival Earth-centred theories of life soon began to irritate an ever-increasing number of scientists in the Western world. Their reaction was a strident rejection of facts, often accompanied by insults and personal attacks that were conducted by proxy in a variety of seemingly reputable internet sites.

It is the present author's view this behaviour has deep sociological roots and is closely related to earlier episodes such as were connected in one instance with the delay in the adoption of the Indo-Arabic numeral system. Empirical science that developed in Europe during the past 4 centuries was firmly based on Western philosophical traditions that date back to the 5th century BCE. With regard to the question of life's origins a strident rejection of panspermia at the beginning of the 20th century left no option but to revert to various modern forms the Aristotelean concept of "spontaneous generation"; and as already mentioned, all these attempts have led to a deep sense of frustration and disappointment. In view of the astounding successes of panspermia such a fundamental failure of Western science to recognise that a change of direction is urgently required is a matter of serious concern.

There can be little doubt that the expansion and dominance of the British Empire from 1600 CE to the mid-nineteenth century shaped the modern world in many ways. The use of English as a world language and the spread of European culture are the clearest examples of this process at work. A more subtle imposition of imperial values was the belief that Western science–science as it developed in exclusively in Europe is the gold standard against which all other traditions of scientific knowledge had to be judged. This necessarily led to the outright rejection of all non-western knowledge systems as well as theories that were seen to have an "alien" provenance. When Fred Hoyle and the present author sought to re-examine ideas of life as a cosmic phenomenon and reconsider panspermia in the 1980's we had unwittingly stumbled upon this seemingly insurmountable cultural obstacle. Over the past few decades the resistance and hostility to the re-emergence of panspermia was possibly exacerbated by the fact that the present author (its main modern proponent) hailed from a non-European ethnicity and a culture perhaps representing a non-imperial knowledge tradition.

Although by the mid-nineteenth century the British Empire had vanished like morning dew, a deeply ingrained hostility to ideas that were seen as "foreign" continued to prevail, and enjoys a long after life in the modern world. A great deal of the science that we accept today, including the unproven ideas of spontaneous generation along with the rejection of panspermia, is part and parcel of "a colonised science". The process of "decolonisation of science" could be seen to have scarcely begun in 2020 (Figure 8).

Figure 8: New York Times racist cartoon making fun of Indian space agency ISRO, which was the first space agency to explore the polar caps of the Moon. A man with a cow knocking at the gate of ISRO with a background of an exploding rocket!

It is imperative that irrational prejudice is shed in favour of the truth no matter where it comes from. With regard to the theory of cosmic biology its impartial evaluation and eventual acceptance might even be crucial for our very survival as a thinking species. I would like to conclude with a quote from a paper. I published in this journal co-authored with GensukeTokoro [43]:

"If a jury comprised of 12 impartial men and women were presented with the full range of evidence on the existence of extraterrestrial life, and the cosmic origins of life, there is scarcely any doubt that the verdict will be positive. So overwhelming is the totality of the evidence we have discussed. Ingress of extraterrestrial life to the Earth would appear to have been established beyond a shadow of doubt.

CONCLUSION

The fact that this conclusion is not widely known or publicised is

in the authors' view entirely a function of state control of scientific paradigms, of a kind reminiscent of the behaviour of totalitarian political regimes. Refusal to conform to the strictures of authority is met with serious consequences that are particularly damaging for young scientists at the start of their careers in science. For them the award of grants to support their work, approbation by peers, or even their very livelihood is threatened. Under such repressive constraints progress toward any form of objective truth is virtually impossible.

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