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ESSAY

Panspermia versus Abiogenesis: A Clash of Cultures

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HIGHLIGHTS

Science has been historically influenced by cultural biases and symbolism, which constrain the consideration or interpretation of certain information and evidence. This situation particularly affects critical questions and research on the origins of life.

ABSTRACT

We are led to believe that from the beginning of the enlightenment in Europe in the 17th and 18th centuries CE, science has moved forward with an abandonment of all forms of irrational prejudice. While we are aware that socio-cultural factors control large areas of science, particularly with regard to the allocation of public funds, we often forget to assess the consequent societal damage. This is true particularly in relation to the biggest questions of science such as the origin of life and the origin of the Universe. In the interests of science, it is important to recognize the role of such influences in the assessment of competing theories, particularly those relating to the origin of life.

KEYWORDS

Panspermia, abiogensis, cosmic dust, bacteria, virus, origin of life, Big-Bang theory

INTRODUCTION

Max Weber (1864–1920), the pre-eminent social philosopher of the early 20th century, in a lecture in 1907 on "Science as a Vocation," articulated the hope that "there are no mysterious incalculable forces" remaining in the world, and that therefore we no longer needed to invoke explanations that lie outside the realm of empiricism" (Weber, 1948; Merton, 1973). A dilemma still to be resolved, however, was how to reconcile this position with the prevailing set of Judeo-Christian cosmological beliefs in the Western world. There can be little doubt that a theologically constrained "First Cause" has silently crept into many fundamental questions of modern science—the origin of Life and the origin of the Universe being perhaps the most important examples.

From the time of the earliest philosophies in classical Greece, the struggle has been to disentangle religion and the "gods" from any 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 comprises invisible particles known as 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 an infinite world. Although most of Epicurus' writings are lost, a long succession of his disciples recorded and transmitted his views, particularly Metrodorus (331–77 BCE). The surviving writings of these later authors bear testimony to a distinctly modern panspermic view of life in the cosmos. Around 400 BCE 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)

These ideas relating to life implied furthermore an infinite Universe that was essentially independent of control by any god or pantheon of gods.

The same freedom from theistic control was implied in the writings of the pre-Socratic philosopher Anaxagoras of Clazomenae (500 to 428 BCE). Although very few of the writings of Anaxoragas have survived, fragments handed down to St. Irenaeus (~200 CE) state clearly that Anaxagoras thought ". . . life was originally generated in moist conditions (Mansfield, 1986); and Theophrastus (born 371 BCE) had reported earlier that ". . . according to Anaxagoras the air contains the seeds of all living things, and that these, carried down by the rain, produce plants . . . " Finally, we have the surviving writings of Diogenes Lucretius (~3 century CE) reporting that Anaxagoras held the universe to be made of particles and also that seeds of life were carried across the cosmos and took root wherever they fell on fertile soil (Theophrastus, 1999). The combination of these reports suggest clearly that Anaxagoras is the originator of panspermic theory, at any rate in its Western tradition.

We should note, however, there are earlier references to panspermia in the wider world outside Europe. Ancient Egyptian papyri and engravings have references to panspermia that go back to the Old Kingdom in Egypt (ca. 2649–2130 BCE), and similar references are also found in the *Rigveda* (1500–1000 BCE) (Temple, 2007). Vedic traditions unequivocally encapsulate ideas concerning the cosmic nature, antiquity, and eternity of life, ideas that found their way into Jain as well as Buddhist philosophy in the 5th century BCE. The non-European provenance of the concept of panspermia, in the author's view, has played no minor role in the development of prejudice against it as well as its persistence even to the present day. Such prejudice is reinforced nowadays by the power of the internet and Google in particular which invariably refers to panspermia as a "marginalized" theory that a majority of scientists choose to disown.

EVOLUTION OF MODERN SCIENCE

In its earliest beginnings, science arose as the solitary pursuit of individual philosophers whose ideas were often opposed to the status quo. Anaxagoras, who introduced ideas of panspermia into the Western canon, also declared that the Sun was a red-hot stone and the Moon was made of earth, and for his heresy he was banished from Athens.

State control of science thus seems to be no new thing. Examples are to be found scattered throughout history—extending from the time of classical Greece, through the long saga of the Ptolemaic epicycles in the Middle Ages, and the control of science by the Papacy stretching through into modern times (Merton, 1973).

The involvement of the State or of large organizations in the conduct of science has become necessary today to varying degrees. This is due mainly to the requirement of large funds to set up projects, which are often expensive and beyond the reach of individual scientists. Moreover, these so-called "big–projects" require large teams of scientists using expensive equipment, so organization and central control becomes necessary. Examples of such ongoing big projects include the space exploration of planets by NASA and other similar space agencies, the Hadron Collider operated by CERN, and major genome sequencing projects in several countries—to name but a few. In all such projects conformity is a requirement for social cohesion, but it also too often stands in the way of progress. In the case of NASA's declared mission to search for extraterrestrial life, the insistence on an undeclared premise that life originated in situ on Earth immediately prejudices the outcome.

European science from the time of the Renaissance onward developed ostensibly to challenge superstition and mysticism—for instance witchcraft and alchemy. The birth of scientific academies in France and England such as the French Academy and the Royal Society are markers of this process. In the process of rejecting superstition, an incidental consequence was also to reject non-Aristotelian traditions of philosophy which included concepts such as panspermia. A more general trend to persist was the rejection of all non-European traditions of knowledge as part of the growing dominance of Western imperial power, and particularly with the rapid expansion of the British Empire through the 17^{th} and 18^{th} centuries.

One remarkable instance of rejecting non-European ideas was the stubborn and continued rejection of the Hindu number system (later called the Indo–Arabic number system). Although knowledge of this number system had undoubtedly reached Europe long before the Middle Ages, its rejection in favor of the cumbersome Roman numerals continued well beyond the end of the 16^{th} century (Cajori, 1993). The first Arab reference to this number system is found in a fragment of writing by the Syrian mathematician and philosopher Severus Sebokht of Nisibis (575–667 CE). Praising the wisdom and scholarship of ancient India he states thus:

> I will omit all discussion of the science of the Hindus, a people not the same as the Syrians; their subtle discoveries in this science of astronomy, discoveries that are more ingenious than those of the

> Greeks and the Babylonians; their valuable methods of calculation; and their computing that surpasses description. I wish only to say that this computation is done by means of nine signs. If those who believe, because they speak Greek, that they have reached the limits of science should know these things they would be convinced that there are also others who know something.

The long delay in the transition to Hindu numerals was undoubtedly connected with a deep-rooted suspicion of the alien non-Christian pagan culture from which this system had emanated. This is an example of the role of cultural supremacy in the sanctioning of philosophical and scientific paradigms. Graeco-Roman science, philosophy, and indeed the whole of classical culture, was regarded as being the direct ancestor of all European culture. Thus no other knowledge tradition was effectively given a look-in.

RESISTANCE TO PANSPERMIA

A rejection of panspermia came scarcely a century after it was first discussed in a Western context by Anaxagoras and Epicurus as we have already noted. This was mainly due to the powerful influence of the philosopher Aristotle of Stagiera (385–323 BCE) who proposed a rival 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 invoked by Aristotle, the doctrine of spontaneous generation of life on the Earth lent itself readily to such an interpretation at a later time.

Aristotle's influence as a pre-eminent philosopher and an astute observer of the natural world is evident in the vast number of surviving texts and commentaries that are still being studied by scholars. Following the adoption of Christianity in the Roman Empire by Constantine in the 3rd century CE it was therefore not surprising that Aristotelean philosophy had to be somehow accommodated. This was accompanied by a firm rejection of the ideas of Anaxagoras, Democritus, and Epicurus, ideas that did not lend themselves as readily to a theistic explanation.

The Aristotelean worldview later came to be fine-tuned by Christian theologians and philosophers, notably Thomas Aquinas (1224–1274 CE), who advocated a strictly geocentric model of the world, one that necessarily also included the concept of life being Earth-centered. A strict allegiance to such a model soon came to be tied up with faith rather than fact, so that overturning it became ever more difficult as the centuries progressed. The concept of a physical universe firmly centered on the Earth persisted for several centuries, but was of course eventually dismantled by the Copernican revolution of the 16th century. The idea of Earth-centered life and biology, however, persisted right through into modern times.

FROM ABIOGENESIS TO PANSPERMIA

At the dawn of the 21st century the fundamental logical choice in relation to the origin of life lay between two competing concepts: (a) abiogenesis—life generated in situ on Earth (following Aristotelian logic) 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 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 roots going back to the pre-Socratic philosophers, and even much earlier to ancient Egypt and to Vedic philosophies of India (Figure 1) (Temple, 2007).

It is interesting to note that over 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 (Wainwright & Alshammari, 2010). However, any 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—for example 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 (Pasteur, 1857). Pasteur thus effectively disproved the reigning dogma of "spontaneous generation," the Aristotlean idea 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 taken up and supported enthusiastically by several distinguished contemporary physicists. For instance, the German physicist Hermann von Helmholtz (von Helmholtz, 1874) 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

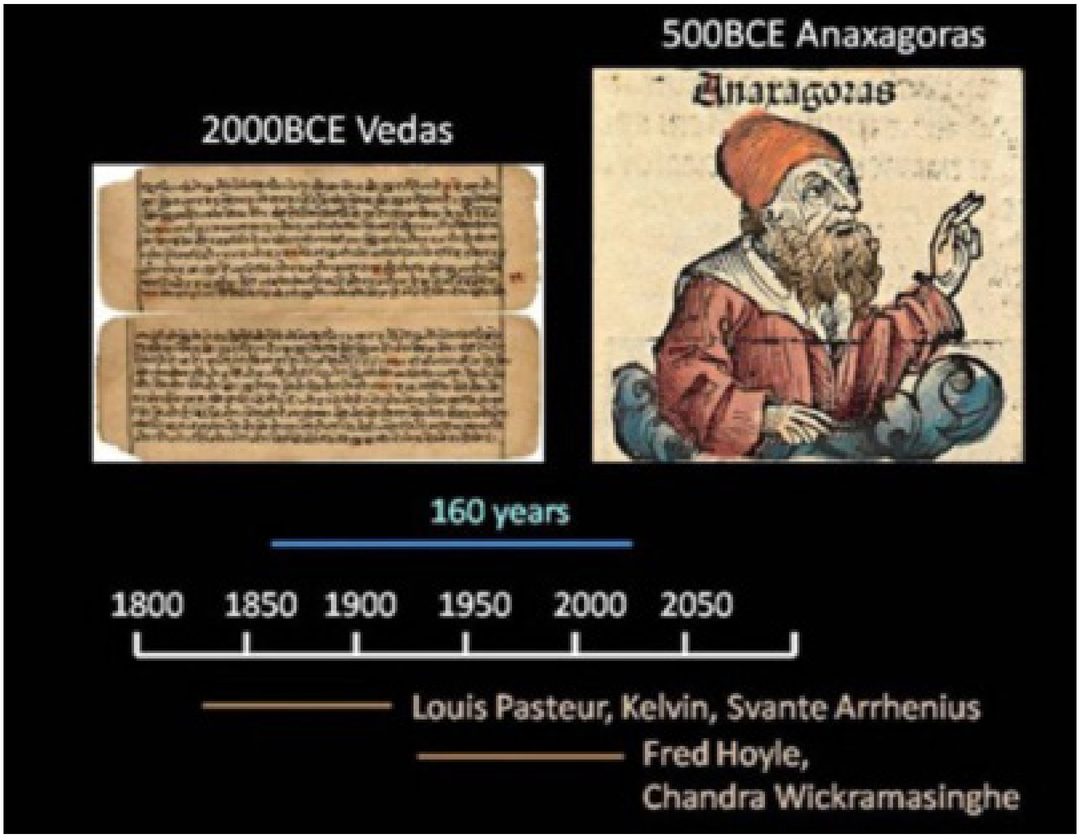

Figure 1. The trajectory of panspermia from prehistory to modern times.

> 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) (Thomson, 1871) 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 proselytized for the "doctrine of panspermia" in his book *Worlds in the Making* (Arrhenius, 1908).

In retrospect it is difficult to believe that all such pronouncements were consistently ignored in the decades that followed. At every turn the Earth-centred Aristotelian point of view of spontaneous generation re-emerged to dominate even the strongest evidence pointing to the possibility of an alternative panspermic viewpoint. Weak and uncertain evidence of the lack of space-hardiness of bacteria was presented in the 1920s 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 found to be false (Wickramasinghe et al., 2010; Wickramasinghe, 2015; Wickramasinghe & Tokoro, 2014a,b). Contrary to what is often wrongly stated, in popular as well as more scientific writings, panspermia in 2022 is the furthest removed from mere speculation; rather it is firmly rooted in data and irrefutable facts (Hoyle & Wickramasinghe, 2000).

FAILURE OF LABORATORY EXPERIMENTS TO SUPPORT SPONTANEOUS GENERATION

The functioning of a living system depends on thousands of chemical reactions taking place within a membrane-bound cellular structure. Such reactions, organized in groups 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 the cells, building biopolymers of various sorts, and ultimately making copies of itself possessing a capacity to evolve. Batteries of enzymes, comprising chains of amino acids, play a crucial role as catalysts precisely controlling the rates of chemical reactions. Without enzymes there could be no life.

In present-day biology the information contained in the enzymes—the arrangements of amino acids into folded chains—is crucial for life, and this information is transmitted via the coded ordering of nucleotides in DNA. In a hypothetical RNA-world that may have predated the DNA-protein world, RNA is posited to serve a dual role as both enzyme and genetic transmitter. If a few ribozymes are regarded as precursors of all life, one could attempt to make an estimate of the probability of assembly of a simple ribozyme comprising 300 bases. This probability turns out to be 1 in 4^{300}, equivalent to 1 in 10^{180}, which can hardly be supposed to happen even once in the entire 13.7 billion year history of the entire universe. It is therefore not surprising to find that after nearly half a century of experiments in laboratories around the world no progress can be seen to demonstrate the process of spontaneous generation of life (Wickramasinghe et al., 1996). The failure to witness any trend whatsoever toward the emergence of a living system is normally attributed to the infinitesimal scale of the laboratory system when compared to the postulated terrestrial setting in which life is thought to arise. Yet, if we move from the laboratory flask to all the oceans of the Earth we gain in volume only a factor of $\sim 10^{20}$, and in time from weeks in the laboratory to, say, half a billion years, the gain is a factor of 10^{10}. In the probability calculation for the single ribozyme we thus gain only a factor of 10^{30} in all, reducing the improbability factor stated earlier from 1 in 10^{180} to 1 in 10^{150}. On this basis it is very difficult to avoid the conclusion that the emergence of the first evolvable cellular life form was a unique event in the cosmos. If this did indeed happen on Earth for the first time, it must be regarded as a "near miraculous" event that could not be repeated elsewhere, let alone in any laboratory simulation of the process. To overcome improbabilities on the scale involved here, it stands to common-sense reasoning that one would gain immensely by going for the biggest system available. And the biggest available system is 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 is by no means scientific. The question whether life started de novo on Earth, or was introduced from the wider universe, is a fully scientific inquiry that merits investigation—one that is open to test and verification in various ways.

Ultraviolet and infrared spectral signatures that could be regarded as having a connection with biology are present everywhere in the universe—from the solar system to the most distant galaxies, even to distances exceeding 8 billion light years. The total amount of such organic material in our galaxy alone amounts to nearly one third of all the carbon in interstellar space. The possibility that all this organic material is the result of prebiotic chemical evolution is mere wishful thinking—particularly in view of the combinatorial arguments to which I have already alluded. Whenever similar spectroscopic features are found on the Earth we attribute them without hesitation to degradation products of biology—indeed well over 99.99% of all the organics on Earth are indisputably biogenic.

We appear to be forbidden by culture and convention from adopting the same logic we apply on Earth to a cosmic scale—the argument being that life outside Earth is an extraordinary claim for which extraordinary evidence is called for. On the contrary, the confinement of life to the Earth can be regarded as the extraordinary claim, particularly in view of the multiple dynamical pathways available for interstellar and interplanetary transfers, and the survival properties of bacteria that have been identified and documented (Wickramasinghe et al., 2020).

GROWING INDICATIONS FOR COMETARY PANSPERMIA

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 procedures in a Popperian sense. At the present time all such tests for spontaneous generation have produced null or at best ambiguous results as we saw earlier, whereas a wide range of tests of panspermia have led to a positive outcome. These latter results are summarized in this section.

From the 1970s onward, the present author, in collaboration with the late Sir 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 (Wickramasinghe et al., 1996). 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.

I will not dwell on details of evidence here but only summarize the salient facts that have been amply discussed in a long series of recent books and technical papers (Wickramasinghe et al., 2010; Wickramasinghe, 2015; Wickramasinghe & Tokoro, 2014a,b; Hoyle & Wickramasinghe, 2000). The following timeline of developments is worthy of note:

- 1962: The prediction and discovery that carbon was the main component of cosmic dust.
- 1974: The identification of organic polymers making up the bulk of interstellar dust, suggesting they may be the break-up products of bacteria and viruses.
- 1977: The epidemiology of an outbreak of H1N1 influenza that was consistent with viral ingress from space (Hoyle & Wickramasinghe, 1979).

- 1982: A prediction of the detailed mid-infrared absorption spectrum of interstellar dust based on prior laboratory experiments that was verified later by observations of the galactic infrared source GC-IRS7 (Hoyle & Wickramasinghe, 2000). We have regarded this as a crucial step in establishing panspermia as a process that satisfied a crucial "Popperian" test. These new infrared observations have been more conservatively interpreted by critics as merely representing the complex organic building blocks of life on a vast cosmic scale, with their assembly into primitive life occurring in cosmically augmented "primordial soups" on Earth-like planets. An objection to this is that organic molecules are a far cry from the simplest form of microbial life. The improbability of their assembly to such microbes have been shown to be on a superastronomical scale—pointing to an origin of life encompassing cosmological dimensions of space and time (Hoyle & Wickramasinghe, 2000).
- 1986: A prediction of the detailed mid-infrared emission spectrum of the dust tail of comet P/Halley based on prior laboratory experiments for freeze-dried bacteria (Hoyle & Wickramasinghe, 2000).
- 1996: Eruption of Comet Hale Bopp at large heliocentric distance at 6AU (Wickramasinghe et al., 1996).
- 2001: Prediction of bacteria entering the stratosphere verified at a height of 41 km (Harris et al., 2002).
- 2015: Rosetta Studies of Comet 67P/Churyumov–Gerasimenko showing consistency with the presence of bacteria (Wickramasinghe et al., 2015).
- 2016: Earliest evidence of life on the Earth during the Hadean epoch during a time of comet impacts (Bell et al., 2015).
- 2018: Microorganisms found on the outside of the International Space Station 400 km above the Earth (Grebennikova, 2018). 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 addition to such explicit verifications of prior predictions, there was also the discovery after 2001 of unmistakable "viral footprints" in our own DNA and the DNA of plants and animals confirming the prediction from panspermia of cosmic viruses driving biological evolution on the Earth (Hoyle & Wickramasinghe, 1982; Wickramasinghe, 2012; Steele et al., 2018). Other astronomical and biological data decisively supporting panspermia is further summarized in two recent reviews by Steele et al. (2018, 2019).

The partial list given above can be enlarged to include more detailed facets of correspondence between the predictions of the panspermia model and a diverse set of observations. I would argue that no wrong theory can be characterized by such an impressive record of detailed predictions of being unfailingly verified. It appears ironical that the stronger the supportive evidence has become for panspermia in recent times, the ferocity and the irrationality of opposition to it has grown stronger. It is becoming amply clear that cultural influences are beginning to play a decisive role in attempting to stall a long overdue paradigm shift in science. It is also my view that a hidden reason is that the concept of panspermia could be interpreted as being at odds with Graeco-Roman and Judeo-Christian traditions of religion and philosophy.

An aspect of panspermia that has been subject to much ridicule is the idea that viral and bacterial pathogens responsible for epidemics of disease could have an ultimate space origin. 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 as indeed all pandemic viruses cannot be ruled out (Hoyle & Wickramasinghe, 1979; Steele et al., 2020). Many aspects of the epidemiology of this new virus supports the idea of a primary atmospheric fallout modulated by atmospheric turbulence over several scales and followed by person-to-person spread. The disentanglement of the two processes presents a continuing challenge to scientists.

It is worth noting in this context that the total viral content of the Earth is truly astronomical and is by no means fully charted. For example, a single litre of seawater collected in marine surface waters has been estimated to contain more than 100 billion viruses—the vast majority of which remain unidentified (Furnham, 1999; Parsons et al., 2012). The total viral content of the oceans is estimated to be in excess of 10^{30}; the vast majority of identified species are informationally rich bacterial phages, but with a hitherto unknown component of other viruses also included in this tally. While this number does not represent genetically distinct phages, it is nevertheless astoundingly superastronomical, exceeding 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 the possible connection between life on Earth and the wider cosmos.

A SUMMING UP OF THE EVIDENCE

In the past five decades abiogenesis has been confronted with a formidable array of new facts from astronomy, geology, space science, and molecular biology, all of which may have challenged its validity. Simultaneously an ever-increasing number of predictions of panspermia has come to be verified to an astounding degree of precision. Wrong theories do not perform in this way, so it soon became clear that panspermia's star was on the ascendant! The sociology of science now took over: The apparent triumphs of panspermia over rival Earth-centered models of life began to irritate an ever-increasing number of scientists. This was aggravated by the fact that all attempts to demonstrate the validity of Earth-bound abiogenesis in the most advanced laboratories in the world have consistently led to dismal failure (Deamer, 2012).

A decisive demonstration of ongoing panspermia is the only way to resolve the cultural impasse we have reached. Such an experiment is well within the range of our current technological capabilities although it lies outside the scope of individual enterprise by lone scientists or even small groups. In 2001 a group of us working with the Indian Space Research Organisation (ISRO) collected and analysed cometary material that reached a height of 41 km in the stratosphere and discovered evidence for 0.1 tonne of microbes reaching the Earth every single day (Harris et al., 2002). Repeating this experiment—collecting microbiota at 41 km or higher and searching for evidence of biological structures that have a characteristic non-terrestrial isotope signature is well within the technological capabilities of space agencies in 2022. The fact that this has not been done until now, or even planned for the foreseeable future, is an indication of hostility to the concept of panspermia in my view. For the exponents of spontaneous generation theory, the answer is deemed to be already known—so the general reaction is—why bother? This attitude might possibly buy time for a doomed theory, but the Universe will always have the last say!

The timeline of panspermia from its early roots in the Vedas through to Anaxagoras in the 5th century BCE and into modern times is sketched in Figure 1. The last phase following on from Arrhenius led up to the verification of predictions described earlier. As we have noted, this unfolding scientific drama summarized above, is well-documented in a large corpus of scientific papers and recent books to which reference has already been made.

FROM BIOLOGY TO COSMOLOGY

We have argued in earlier sections that panspermia is well within sight of being proved and will be possibly be proved beyond any doubt in the near future. Similarly, it could be shown that the spontaneous generation of life from non-living chemicals will be proved to be impossible and untenable—requiring the overcoming of a superastronomical information hurdle as we have noted earlier. So one might well ask: Where are we in the search for our ultimate origins? This question is intimately linked to cosmology—is the universe finite or infinite? If the latter is the answer, the information content of all life is an essential component of the Universe—dispersed as viruses and bacteria available for assembly on every habitable planetary body that forms within it.

In Vedic cosmology the universe is thought to be infinite in spatial extent and cyclic in time—strikingly reminiscent of the modern versions of oscillating universe models. In this context it is worth noting that the currently favored Big-Bang theory of the universe with an age of 13.83 billion years is by no means absolutely proven. The very recent discovery of a galaxy designated GN-z11 located at a distance of 13.4 billion light years (implying its formation just 420 million years after the posited Big-Bang origin of the universe) poses serious problems for the current consensus view of cosmology (Jiang et al., 2020). Similar problems for the Big-Bang cosmological model have been discussed over a period of some 3 decades by small group of dissenters including Fred Hoyle, Geoffrey Burbidge, and Jayant Narlikar (Hoyle et al., 2000).

Recently, Nobel Laureate Roger Penrose has joined a select group of dissenters who challenge the standard view of a unique Big-Bang origin of the universe 13.83 billion years ago (An et al., 2020). In a theory called the "conformal cyclic cosmology," Penrose postulates that the universe undergoes an infinite number of cycles in which the Big-Bang event 13.8 billion years ago is the most recent cycle, and of which we are a part (see Figure 2). In such a class of models the origin of life and the origin of the universe are inextricably intertwined.

As I have already mentioned, clinging to cultural norms and symbolism has been common throughout history and has pervaded diverse cultures. But when there is not a great deal that rests on such symbolism it is not a matter of much consequence. The worship of Athena, for instance, served to maintain the integrity and unity of the city states of classical Greece, and although this was of course thoroughly irrational, it clearly did not detract from glories and intellectual achievements that followed! Unfortunately, a great deal does, however, rest on the acceptance or otherwise of theories relating to life in the universe.

IMPLICATIONS AND APPLICATIONS

A critical analysis of the panspermia/abiogenesis debate in relation to a large and diverse body of data as it has evolved over several decades has shown the role of cultural filtering of evidence that has undoubtedly skewed public perceptions. A similar process occurs in other multidisciplinary areas of science, and it is necessary to be aware of this process to minimize damage and arrive at ultimate "truths."

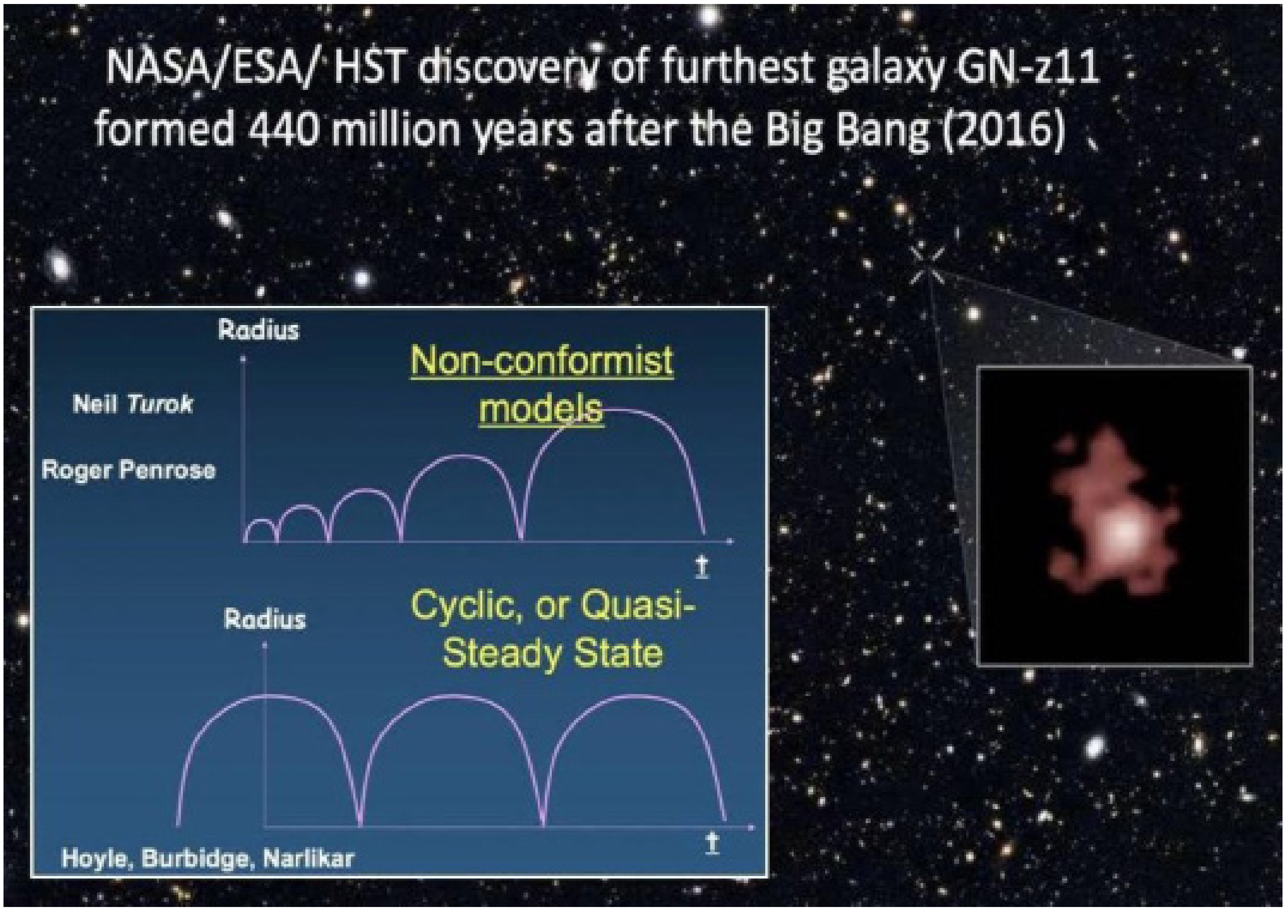

Figure 2. The most distant galaxy GN-z11 located at a distance of 13.4 billion light years from Earth challenges the consensus Big-Bang model of the universe.

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