Panspermia-Nature's Exercise in Microbial Cultivation on a Vast Scale

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Abstract

Although the idea that life on Earth originated from space has a long history, the modern version of the theory was developed by Hoyle and Wickramasinghe as their cometary theory of panspermia. This theory is discussed here from a microbiologist's point of view, i.e. the prebiotic Earth is seen as a vast culture vessel containing both Earth and space–derived nutrients. This vast culture medium was then, we suggest, naturally inoculated by microbes from space. Life may have arrived as a single organism, but more likely it did so in the form of a mixed "inoculum". Once established in the Earth's culture medium the incoming organisms would have replicated rapidly to from a huge biomass made up of a "mixed culture" of microorganisms representing all of the major metabolic strategies, such as heterotrophs (including oligotrophs), chemoautotrophs and phototrophs. The dominant organisms would arise sequentially depending upon the prevailing physical conditions and to the existence of inter-microbe competition. The incoming mixed inoculum is considered to have originated form comets which, as suggested by Hoyle and Wickramasinghe, provide vast incubators, collectors and deliverers of this inoculum to Earth and the wider cosmos.

Key words: Panspermia, astrobiology, cometary panspermia

Introduction

The idea of panspermia, and many of the seemingly modern speculation on the origin of life- the arrival of organic material from space and the possible of life, intelligent of otherwise in space, has long been suggested (Wainwright, 2010a). Schaler (1869) nearly a decade after the appearance of *On the Origin of Species* could, for example, state that:

Organic life is the product of forces which arrive at the surface of the Earth from two different directions; the one descending to us from the sun, the other coming up from the central regions of the Earth...All the force which enters into the development of life has a celestial origin...

Similarly, the idea of that life originated from space and not on Earth (although both could have occurred) has a long history as can seen from this quote made by Free (Free,1923), which essentially gives the current view of panspermia:
Distinguished scientists have believed it possible that the germ of life first came to Earth from another planet: hidden perhaps in the crevices of a meteorite or merely as living dust floating through space.

The modern theory of panspermia began with the seminal work of Hoyle and Wickramasinghe which appeared in the late 1970s (Hoyle and Wickramasinghe, 1982, 2000, Wickramasinghe, 2004, Wickramasinghe et al., 2010). A particularly novel aspect of their approach was the suggestion that life on Earth not only originated from space but continues to arrive from this source even today (so-called neopanspermia, Wainwright,2003.). This idea should have alerted biologists to the fact that Earth is an open system and terrestrial life is influenced by chemicals and physical objects (such as asteroids), which enter from space; equally life and both chemicals and physical objects, exit the Earth into space. While the view that water and the potential chemical precursors for life came to Earth from space has recently entered the scientific mainstream the view that life on Earth might have originated on Earth from this source remains heretical and continues to be ridiculed. Why this should be remains a fundamental mystery, especially considering the growing evidence in its favour.

Here, we wish to discuss both panspermia and neopanspermia, placing particular emphasis on the way that the ideas of Hoyle and Wickramasinghe have influenced, and continue to influence, the development of these ideas. We will use the analogy here that the appearance of life on Earth can be viewed as vast, natural, exercise in the culturing of microorganisms.

Microbiologists routinely grow microbes in liquid nutrient solutions, or on solid agar nutrient media. In both cases the nutrient source is inoculated with the microorganism or mixed culture of microbes under study. The nutrient solutions or agar plates are then incubated at a suitable temperature over a time period to allow the bacteria or fungi to grow rapidly. The prebiotic Earth can be regarded as such a culture medium but on a vast scale, and of course not initiated by humans. In order for life to begin on Earth in this way a nutrient medium and a source of the microbial inoculums is required.

Sources of nutrients

Microorganisms need nutrients to grow. All organisms require carbon in the form of compounds such as sugars and amino acids, while green plants, algae and chemoautotrophic bacteria get their carbon by utilizing carbon dioxide. Organic carbon compound could have been formed on the prebiotic Earth in the manner suggested by the Urey-Miller experiments, or (as well as, perhaps) been delivered by extra terrestrial bodies such as comets, meteorites and asteroids. Whatever the source, microorganisms arriving to Earth from space would find a vast nutrient solution ready for them to exploit.

Comets and meteorites: The origin of the inoculum

The modern theory of panspermia proposed by Hoyle and Wickramasinghe suggests that comets provided the source of inoculum to the pre-biotic Earth (and continue to supply microbes to the planet). They suggest that comets are vast incubators of microbial life which spew microorganisms from their tails as they traverse space. From what we are currently learning about comets this, at first sight, fanciful idea is increasingly becoming plausible. Comets contain water and huge variety of organic and inorganic compounds; parts of them reach temperatures which are optimal for microbial growth (i.e. circa 40^0C), while higher and lower temperatures will exist which are able to support a range of temperature-related extremophiles. Conditions within the comet could allow for all of the variety of microbial physiologies exhibited by present day Earth microbes. For example, aerobic and anaerobic areas of the comet will exist as will reduced forms of inorganic compounds, such as elemental sulphur, ferrous and manganous ions which can support chemoautotrophs in the areas which lack organic carbon. Gases such as hydrogen, hydrogen sulphide, oxygen and carbon dioxide are likely to be present, which can add even more variety to the envisaged cometary microbial flora. Areas of the comet will be exposed to sunlight and carbon dioxide which would provide ideal conditions for the growth of photoautrophs. Finally marked variations in pH are likely to occur, which will support both acidophiles and alkalophiles

A frequent, spurious argument against panspermia is based on the innovation of Occam's razor (care should always be taken not to cut oneself on Occam's Razor!), namely that if life originated somewhere then that "somewhere "could have been Earth and there is no need to invoke an extraterrestrial origin. Of course this limits the origin of life to a small rocky insignificant planet placed at the edge of an insignificant galaxy. When the origin of life is removed from Earth then the physical places in which it could have happened and the time available becomes vastly increased. Despite this, Hoyle and Wickramasinghe maintain that even with this increase in time and space, the origin of life (again, if it ever occurred anywhere) was a statistically remote event, to the point where it becomes highly improbable. Finally, although Hoyle and Wickramasinghe emphasise cometary panspermia they do not exclude the view that life could have arrived to Earth in a meteorite, this view is related to cometary panspermia by the fact that comets evolve meteorites.

Earth as a vast mixed culture vessel

The present scientific consensus is that all the amazing diversity of life on this planet originated here; the first proto-life originating when simple chemicals came together on the prebiotic planet - the rest being produced as the result of evolving complexity from this very simple origin. This may indeed have happened but considering the vastness of space it seems perverse to suggest that life must have originated (if it ever originated) only once on this astronomically insignificant planet. On the other hand if life did have a starting point it may have originated on this planet and nowhere else; it may in fact be unique to Earth. An alternative, middle way is that life originated here on Earth but has also been augmented by microbial life from elsewhere.

Let us consider how microbial life might have arrived and become established on our planet (and presumably other potential planets). In this view, we see that life has been arriving to Earth since its inception, but the arriving microorganisms obviously had to wait until the conditions of the Earth's surface were sufficiently ambient to allow for survival and then growth. This view does not exclude the possibility that some of these arriving microbes were able to survive deep in the Earth's crust or deep oceans which would give the impression to present day investigators that life on Earth originated in these environments. The Hoyle and Wickramasinghe theory of cometary panspermia suggests that microorganisms arrived to Earth inside the vast amounts of water delivered here by comets, although they would have arrived from this source before this point and also subsequent to it. A solitary organism, or more probably a mixed population, would have arrived, the composition of these inputs would be ever changing over time and individuals would be selected for by the environment and by inter-organism competition. An ever varying interplay of catastrophes, and ever changing environments, would also select for individual microorganisms. The organisms, or mixed populations would vary in relation to their metabolic strategies. Thus photoautotrophs might arrive before chemoautotrophs or *vice versa*, or they might arrive together, again to be operated upon by selection. Any organism or organisms, or indeed a proto-organism, which arrived early on in the process might be able to take advantage of the lack of competition and because of rapid doubling time (particularly of bacteria) would increase rapidly in numbers until it occupied the whole of the Earth's available niches. These early invaders would then be superseded by others, so that "blooms" or consortia, based on the temporarily dominant metabolic group, would predominate. Once microorganisms became established they would soon change the geology by their ability to, for example, oxidize and reduce iron sulphur and manganese and produce gases such as oxygen and methane. It is often suggested that chemoautotrophs would be the first organisms to be established on Earth on the assumption that there would be little in the way of carbon-based nutrients to support heterotrophs, but since large amounts of organics might be produced on Earth or supplied by comets so that the establishment of heterotrophs need not be limited by a lack of available carbon. If carbon supplies were, at any point in the process, meagre then oligocarbotrophic and oligonitrotrophic heterotrophs could still survive and exploit the prevailing low-nutrient conditions. The establishment of an atmosphere would eventually protect Earth organisms from one, ongoing catastrophe, namely the presence of highly damaging UV-light; once this protective atmosphere had developed than microbes could leave the protection of the rocks, oceans and soils to begin colonizing the exposed surface of the planet. Ironically this protective cloud layer would reduce the rate of UV-induced mutations, but as we shall see later a system operates to carry Earth-bound organism into the mutation laboratory of the stratosphere where they can be exposed to UV and then return back to Earth following sedimentation and hear evolve more rapidly than organism which did not journey into the stratosphere (Wainwright, 2010c).

Panspermia and the formation of terrestrial biofilms

Although the majority of research studies conducted on microorganisms involves growing microbes in constantly moving liquid nutrient medium most microbial life on Earth does not occur in the "planktonic phase", but instead in the form of so-called biofilms. A biofilm is an extremely thin film of microbial biomass which occurs on surfaces such as rocks in rivers and oceans and incidentally on human teeth. Biofilms are made up of assemblages of many organisms which grow together and constantly interact with each other. The formation of biofilms is a potentially important occurrence since biofilms are made up of a wide range of physiological types of microorganisms, i.e. they show physiological heterogeneity (Stewart and Franklin, 2008) and gene transfer between these diverse cells occurs at a much higher frequency than between isolated, planktonic cells Molin and Tolker-Nielsen (2003). Biofilms made up of panspermic-microbes could therefore be the most efficient mechanism for encouraging the transfer of genes and therefore the evolution of microbes to metazoans and then higher organisms.

Neopanspermia

If life on Earth came from space it must continue to do so; in this respect nothing has changed since the origin of the Earth. The theory of neopanspermia predicts that microorganisms are currently arriving to Earth in meteorites or in the vast amounts of comic dust which are daily incident on the Earth (Wainwright et al., 2002, Wainwright, 2010c). Most astrobiologists would consider meteorites to be the most likely transfer vehicle of the space-derived microbial inoculums (simply because it provides a more obvious mechanism for protecting microbes from the extremes of a journey through space), but microbes living within protective layers of cosmic dust would also likely survive the passage from comets, or elsewhere to Earth. It is important to recognize however, that even if microorganisms are proven not to be currently arriving to Earth at the present time, the theory that life on Earth originated from space, and was delivered by meteorites or in the early deluges of cometary water would not be invalided. Recent research aimed at demonstrating neopanspermia, especially the finding that microbes can be isolated from the stratosphere, is discussed by Wainwright (2003, 2008, 2010c), Wainwright et al. (2003), Shivaji et al.(2009).

Pathospermia

Hoyle and Wickramasinghe claim that microorganisms, which are pathogenic to humans, also arrive from space and thereby provide act a source of new pandemics. Of all of Hoyle and Wickramasinghe's ideas this has been the one which has been most often ridiculed and summarily dismissed. However, if comets, or some other extraterrestrial source, currently provide microbes to Earth then it is illogical to assume that this influx would be restricted to saprophytes only. Microbes growing within comets would undergo mutation and evolution and there is no reason to assume that such mutations could not randomly create a virus or other microbe that could not act as a pathogen when it meets a suitable host. The view that a pathogen must be "aware" of its host before it could be adapted to it is widely used to exclude

Hoyle and Wickramasinghe's pathospermia theory, but the possibility is clearly open to question and this criticism could be readily circumvented by the simple expedient of assuming that there is a time lapse between the organism arriving from space to Earth during which it accommodates itself to its new found host, i.e. humans.

Conclusion

Neither Sir Fred Hoyle, nor Chandra Wickramasinghe were biologists, so when they proposed their ideas of cemetery panspermia they had to acquire an sufficient understanding of these scientific fields to provide a convincing biological theory. Scientists jealously guard their terrain, a fact which helps in part to explain why this modern version of panspermia was derided when suggested by Hoyle and Wickramasinghe, a process which largely continues today. Why this should be probably lies in the fact that, with a few exceptions, modern biologists remain essentially geocentric in their outlook. Some microbiologist do of course oppose panspermia, from a rational standpoint often basing their objections on the claim view that microbes could not withstand long-term exposure to the space environment. Despite this, most modern biologists see the Earth as an isolated, closed system on which life necessarily originated and with the evolution of life has been only influenced by Earth–related forces, this despite the fact that cosmic invents are involved in the development of life on Earth has long been speculated upon, as the following quote from the 1920s shows:
X-rays as well as cosmic rays from outer space may actually be the cause of and motive power behind evolution (Free, 1929).

Free (1929) also claimed that variations in cosmic rays have a influence on evolution, causing it to occur in jumps, leading to dramatic events such as the Cambrian explosion. Yet how often is this rational idea taken seriously by biologists in general, and evolutionists in particular?

Students of the history of biology will recognize that an inevitable momentum has built up around the Hoyle and Wickramasinghe theory of panspermia. While it is always dangerous to predict the future of science (Alfred Russel Wallace for example happily predicted that phrenology would be the science of the twentieth century!), we have no reluctance in predicting that biologists of the second half of this century will find the idea that life originated on Earth, and did not arrive from space, as absurd as we nowadays view Wallace's pet subject, phrenology.

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