

NECROPANSPERMIA

By Paul S. Wesson

*By University of Waterloo, Ontario,
and Herzberg Institute of Astrophysics, Victoria, Canada*

Life on Earth may have been seeded by the arrival from space of radiation-driven grains carrying *dead* micro-organisms like viruses whose *information* content kick-started evolution.

Life might in principle be seeded throughout the Milky Way by astronomical means; but a recent comprehensive review of traditional panspermia confirms that the theory is hardly viable in practice, because microorganisms are deactivated or killed by radiation in space¹. However, it will be argued below that this is not necessarily the end of the theory but rather a beginning. The arrival of *dead* micro-organisms, such as viruses, could have provided the essential *information* needed to start the evolution towards complex biological systems on a planet like Earth.

History shows that panspermia is a perennial idea. In 1871, Lord Kelvin suggested, in an address to the British Society for the Advancement of Science, that life could be distributed through space on rocks such as meteorites. In 1908, Arrhenius argued in his book *Worlds in the Making* that the dominant mechanism was the radiation pressure from stars like the Sun, acting on organism-laden dust grains². Many subsequent versions of panspermia were variations on this theme, using various natural phenomena. By contrast, in 1973 Crick & Orgel proposed that life was deliberately seeded in the early Milky Way by an advanced race using spacecraft laden with DNA-rich micro-organisms³. More recently, natural processes have again been in focus, and data sets from spacecraft and genome studies have been used to provide the astronomical and biological components of more sophisticated versions of panspermia⁴⁻¹².

Despite this continual interest, a problem persists: complex organic molecules such as DNA and RNA are relatively fragile, and easily damaged by electromagnetic radiation (especially ultraviolet) and particle radiation (especially cosmic rays), so it

is reasonable to ask why panspermia continues to be discussed. The answer is that without it there is a countervailing problem of even larger proportions: the 4.5×10^9 years age of the Earth is not long enough to allow for the creation of complex biological molecules if they evolve by random chemical processes in normal planetary environments. For example, on the primitive Earth with an appropriate complement of amino acids, random molecular interactions would only produce about 200 bits of information over the time preceding the first fossil evidence of life, which is tiny compared to the 10^5 bits in a typical virus or the 10^7 bits in a typical bacterium. The low gain in information from a number of trials is given by $I = \log_2 N$ assuming binary encoding, so there is simply not enough time to accumulate the information encoded in the genomes of present-day organisms. It is possible, in theory, that the development of life on the Earth may have involved some form of 'directed' evolution. If the change in the information content of a large molecule is proportional to the amount of information already present, there will be an exponential growth in biological complexity, analogous to a runaway reaction in nuclear physics. However, there is no experimental basis for directed or super-fast biological evolution. In short, the life-forms of the present Earth appear to be too complex to have evolved here, hence the recurrent appeal of panspermia.

It is apparent that the main objection to panspermia, namely that micro-organisms cannot survive damage in space, can be circumvented if the view is taken that it is the *information* content of the molecules which is critical, not the question of whether their host organisms are alive or dead. From the informational viewpoint, a broken piece of DNA in a dead organism is as valid as a whole molecule in a living organism.

Given this view, two questions arise. First, what is the physical mechanism which transports genetic information around the Milky Way, and was presumably responsible for seeding the Earth? Second, what is the biological nature of the precursor material, and in particular the primitive predecessor of life on Earth?

The first of these questions can be answered with some reliability^{1, 4, 6, 9, 10}. Radiation pressure from the Sun causes dust grains of 10^{-5} cm size and smaller to 'leak out' of

the Solar System at a speed of order 10 km sec^{-1} . Dust grains of this type would have been particularly plentiful in the early Solar System, by virtue of impacts on the Earth and other planets by asteroids and comets. At the noted speed, grains reach nearby stars in 10^5 – 10^6 yr, and can populate the optical disc of our Galaxy in a time of order 10^9 yr. Micro-organisms embedded in such grains would be partially shielded from radiation in the originating and destination system, and in interstellar space. Of course, by the time the grains are decelerated into a new system in a reciprocal manner to how they are accelerated out of the original system, the organisms will be dead. But this is, by hypothesis, no longer a fatal objection to the theory. Indeed, the appropriate view of the Milky Way is now one of a cloud of genetically-laced dust, slowly churning under the pressure of its component stars.

The second question posed above, concerning the biological nature of the material which seeds new life, is harder to answer. However, viruses are suitable candidates^{1,7,11, 12}. They have sizes of 20–300 nm (*i.e.*, of order 10^{-5} cm), are fairly robust, and have nucleic acid molecular weights of order 10^6 – 10^8 . The identification of viruses as the precursors of more complex life-forms may be surprising to some biologists, who have traditionally assumed the reverse relationship because modern viruses require the medium inside a cell for existence. A closer examination of the physical nature of viruses shows, though, that they could have thrived in the environment of the primitive Earth; and there are viable models of the early viral world^{11, 12}. It is of course commonly stated that viruses are not really ‘alive’, because the modern ones are simple in structure and cannot reproduce without a host cell. But it is their primitive nature which makes them attractive as agents in panspermia. The philosophical quandary about what is ‘alive’ or not is here sidestepped, by reason of the hypothesis that it is *information* which counts, not vivacity.

Panspermia as a theory is certainly more alive than dead. Indeed, with modern data from astrophysics and biophysics, it is viable in a form close to how it was originally conceived by Kelvin and Arrhenius more than a century ago. However, the modern theory has a new twist, forced by the fact that the radiation which powers the dissemination of dust grains also implies the death of any micro-organisms they may carry. Discounting the incidental aspect of whether something is alive or dead, and

concentrating on the more pertinent consideration of information, it is quite feasible that the Milky Way has been seeded by pieces of complex molecules like DNA or the bodies of dead viruses. How these might evolve into more lively specimens can be tested by carrying out laboratory experiments under conditions reproducing those of early Earth. It is also possible to test the theory by collecting material directly from space. Such retrieval missions should be undertaken in the *outer* Solar System, because the inner parts are already contaminated by human activity, including the dumping of faeces from manned space missions. A proof of necropanspermia would be the isolation, either in the laboratory or in space, of a complex molecule which can withstand vacuum and radiation but lead in a suitable environment to the emergence of something that is alive.

Acknowledgements

This work is based on earlier collaborations with biophysicist J. Lepock and astrophysicist J. Secker. It was supported in part by N.S.E.R.C.

References

- (1) P. S. Wesson, *Space Sci. Rev.*, in press, 2010.
- (2) S. Arrhenius, *Worlds in the Making* (Harper and Row, New York), 1908.
- (3) F. H. C. Crick & L. E. Orgel, *Icarus*, **19**, 341, 1973.
- (4) H. J. Melosh, *Nature*, **332**, 687, 1988.
- (5) T. Lindahl, *Nature*, **362**, 709, 1993.
- (6) J. Secker, J. Lepock & P.S. Wesson, *Astrophys. Sp. Sci.*, **219**, 1, 1994.
- (7) C. B. Cosmovici, S. Bowyer & D. Wertheimer (eds.), *Astronomical and Biochemical Origins and the Search for Life in the Universe* (Ed. Compositori, Bologna), 1997.
- (8) F. Hoyle & N. C. Wickramasinghe, *Astronomical Origins of Life* (Kluwer, Dordrecht), 2000.
- (9) M. K. Wallis & N. C. Wickramasinghe, *MNRAS*, **348**, 52, 2004.
- (10) F. D. Adams & D. N. Spergel, *Astrobiology*, **5**, 497, 2005.
- (11) E. V. Koonin, T. G. Senkevich & V. V. Dolja, *Biol. Dir.*, **1**, 29, 2006.
- (12) N. J. Dimmock, A. J. Easton & K. Leppard, *Introduction to Modern Virology*, 6th. Edn. (Blackwell, London), 2007.

The researchers argue that life may have been seeded here on Earth by life-bearing comets as soon as conditions on Earth allowed it to flourish (about or just before 4.1 Billion years ago). RELATED ARTICLES. Previous. Living organisms such as space-resistant and space-hardy bacteria, viruses, more complex eukaryotic cells, fertilised ova and seeds have been continuously delivered ever since to Earth, they continue, so being one important driver of further terrestrial evolution which has resulted in considerable genetic diversity and which has led to the emergence of mankind. Viruses and retroviruses play a critical role in the argument, due to their ability to alter the genetic makeup of the organisms they infect. Directed panspermia is the deliberate transport of microorganisms in space to be used as introduced species on lifeless but habitable astronomical objects. In 1966 Shklovskii and Sagan speculated that life on Earth may have been seeded through directed panspermia by other civilisations.[4] and in 1973 Crick and Orgel also discussed the concept.[5] Conversely, Mautner and Matloff proposed in 1979, and Mautner examined in detail in 1995 and 1997 the technology and motivation to secure and expand our organic gene/protein life-form by. More suitable targets may be identified by space telescopes such as the Kepler mission that will identify nearby star systems with habitable astronomical objects.