Journal of Cosmology, vol 24, number 8, 2014, 12101-12105.

hypothesis

Please cite this article as:

Chandra Wickramasinghe and William E. Smith, Convergence to panspermia. *Hypothesis* 2014, **12**(1): e5, doi:10.5779/hypothesis.v12i1.358

Convergence to panspermia

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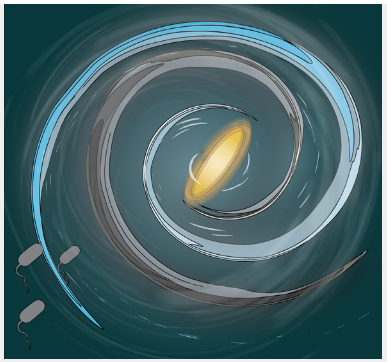

ABSTRACT New discoveries in astronomy and biology continue to point to Panspermia as the most likely mode of the origin of life on Earth. This paper builds upon the work done by W.M. Napier, 2004[1], and re-estimates the time for the seeding of the galaxy given the latest 2013 estimates from the Kepler Mission data. We present this "thought experiment" in the form of an opinion paper. We calculate that, from a single point source of origin, the full colonisation of the entire Milky Way galaxy by primitive microbes will take place in a timescale less than the average age of low-mass stars in the galactic disc, 10^{10} yr (i.e., 10 billion years ago; bya). Our calculation is independent of the location of the "point-source." The writers believe the probability of the point-source being Earth is infinitesimal compared with it being elsewhere in the galaxy.

INTRODUCTION *Scope of this paper*

Although Panspermia, and the Hoyle-Wickramasinghe Model, as an overall hypothesis, could apply to not just our Milky Way Galaxy but to the whole Universe, the scope of the calculation, and thought experiment in this paper, is limited to the Milky Way Galaxy.

Background The earliest evidence of terrestrial life in the form of an enhanced carbon isotope (13C/12C) ratio associated with sediments at 3.82 to 4 billion years ago (bya) coinciding with an epoch of intense comet and asteroid bombardment leads naturally to the hypothesis that the impacts themselves were responsible for the start-up of life on the Earth[2]. The presence of amino acids and nucleobases in the Murchison meteorite has given credence to the more restricted hypothesis that these molecules served as the components of an Earth-based primordial soup from which life was able to originate[3]. However, all attempts to reproduce these processes in the laboratory have so far not been encouraging[4]. The improbability of accomplishing the minimal molecular arrangements, for example, in the order of amino acids in enzymes or nucleotides in DNA, by random shuffling of components has made the once unpopular idea of Panspermia appear increasingly more attractive. An origin of life occurring as a singular cosmic event on a galactic or even cosmological scale transferred via panspermic processes appears to be consistent with all the available data at the present time[5].

Lord Kelvin first suggested that life on Earth may have been carried to Earth via an impacting meteorite, and this idea has recently been recast into the modern form lithopanspermia. This has been discussed recently by several authors in relation to impacts onto a life-laden planet such as the Earth. A comet impact, like that which struck Earth 65 million years ago causing the extinction of the dinosaurs, would also have had the effect of ejecting surface rocks that contain terrestrial microbial ecologies. A fraction of this material can be shown to be able to infect embryonic planetary systems in a nearby molecular cloud[1,6]. The exchange of life-bearing ejecta would have been facilitated between planetary systems that are contained within star clusters. Numerical calculations show how this could be achieved, so panspermic opportunities are optimised in such cases[7].

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Received: 2014/03/14; Accepted: 2014/05/12;
Posted online: 2014/tk/tk

Revisiting The Hypothesis Against which this "Thought Experiment" is Conducted

Our 2013 paper formally documents the Panspermia Hypothesis, and the propositions around which the rapidly evolving evidence should be assessed[8]. We restate this for the convenience of the reader.

The HOYLE-WICKRAMASINGHE (H-W) model of the Panspermia Hypothesis[8]

Panspermia is the hypothesis that life exists throughout the Universe, distributed by meteoroids, asteroids, comets and planetoids.

The Hoyle-Wickramasinghe Model of the Panspermia Hypothesis defines the following propositions to guide the investigation:

Illustration by Eloïse Kremer

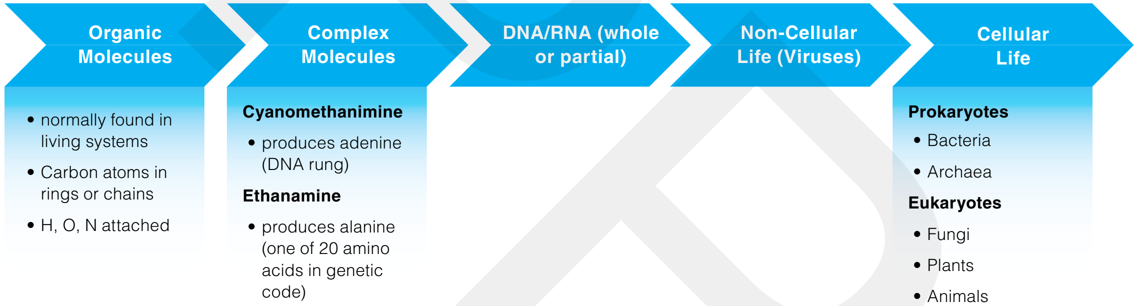

Figure 1 | Seeds of Life

1. That dormant viruses and desiccated DNA/RNA can survive unprotected in interplanetary space (Radiopanspermia)

2. That the seeds of life can survive protected from cosmic rays in asteroids, comets and meteors (Lithopanspermia)

3. That the seeds of life are promulgated from solar system to solar system by a process of comet and asteroid collision with planets; matter ejection from planet to local planets and Moons; and then onwards and outwards from that solar system to an adjacent solar system

In the above propositions of the Hoyle-Wickramasinghe Model, the "seeds of life" include biological microparticles such as bacteria, viruses, spores and pollen (**Figure 1**). This specifically includes:

1. Desiccated and/or partially inactivated DNA/RNA

2. Live, dormant or fossilized non-cellular life (viruses)

3. Live, dormant or fossilized cellular life (bacteria, archaea)

In the more general Panspermia Hypothesis these "seeds of life" are not as clearly defined as in the Hoyle-Wickramasinghe Model. Also in the Hoyle-Wickramasinghe Model, LithoPanspermia includes comets. It proposes that comets are the major promulgation "carrier" of the seeds of life, especially from solar system to solar system, and proposes that the center of comets is mostly water, not ice, an ideal environment for bacteria and viruses.

THE THOUGHT EXPERIMENT *Calculation of the Average Spacing Between Stars*

By March 2014, NASA's Kepler Mission had discovered 5,537 exoplanets (3,845 candidates + 1,692 confirmed). A recent revision of the size of the habitable zones of stars, taking account of atmospheric greenhouse effects, has led to new estimates of the number of potentially habitable Earth-sized planets around low mass stars in the Galaxy as about $N \approx 10^{11}$ [9].

Distributed over the entire volume of the galactic disc $V \approx 7.5 \times 10^{12}\,\text{ly}^3$ (assumed to be a cylinder of radius 50,000 light years [ly] and thickness ≈ 1000 ly), this gives a mean spacing in the galaxy of $(N/V)^{1/3} \approx 4$ ly between stars with habitable planets.

The spacing could be even closer within the birth clusters of stars. Transfer of viable microbial life across such short distances under interstellar conditions would appear to be entirely feasible.

Propagation Method #1: Lithopanspermia: Cometary Panspermia

The H-W Model sees comets as the primary carrier of the "seed of life" (defined above).

For this paper, comets are considered of two types:

- Short-period comets, which live in the Kuiper Belt and have elliptical orbits in the plane of the solar system ecliptic;
- Longer-period comets, which can have elliptical orbits reaching out to the Oort Cloud (but it is the parabolic Comets, which the writers believe have been involved in "sling shot" transfers from an adjacent star system).

These parabolic comets (which the writers believe include comets like ISON with an eccentricity = > 1) are called exo-comets in this paper.

This thought experiment imagines a water-bearing exo-comet heading towards an adjacent Sun-like star. As it gets close to perihelion, with good fortune it not only avoids the large Jupiter-sized inner planets, but again, with luck, finds its perihelion is just far enough away from the star for a large fraction of the comet's mass to make its turn around the star and be slung shot back in the form of fragments and boulders out in a parabolic or even hyperbolic orbit towards our own solar system.

Eventually, these comet fragments coming into the Oort Cloud surrounding our Star (the Sun) are now in parabolic orbits that can interact with Earth and other planetary bodies and transfer life.

Propagation Method #2: Radiopanspermia

Microscopic forms of life are propagated in space, driven by the radiation pressure from stars.

NOTE: This thought experiment is now focused on this second propagation method.

We consider particles expulsed when the comet above reached the perihelion of its encounter with a star[10]. Microorganisms expelled from comets in one planetary system can, under suitable conditions, reach other neighbouring planetary systems through the action of radiation pressure exerted by the light of the central star. The light from the star incident on a virus or dessicated bacterium or clump of bacteria exerts a radially directed outward force P due to transfer of momentum, a photon of energy $h\nu$ carrying momentum $h\nu/c$. The star's gravitational attraction G acts in the opposite direction and both forces vary inversely with distance from the star. For a star like the Sun with a known mass to luminosity ratio, the ratio P/G becomes a property of the particular dust grain model – the clump of bacteria in our case – that can be calculated from the optical properties of the grain material[11]. In situations where the ratio P/G exceeds unity, grains are expelled from the star. Calculations of this ratio for bacterial grains in the form of spherical clumps possessing thin outer skins of reduced carbon (graphite) for particles in the vicinity of the Sun show that we have P/G ratios close to 3.

If such a particle is expelled from a comet at a heliocentric distance of Ro, the particles with P/G > 1 would be expelled from the entire solar system with an asymptotic velocity of:

$$v \cong \sqrt{\frac{2\alpha k M}{R_o}}$$

where α = P/G – 1, k is the Universal Gravitational constant, R_0 = 1 and M is the solar mass. For $\alpha = 0.5$, P/G = 1.5 in a typical case we get:

$$v \approx 3 \times 10^6 \text{ cm/sec}$$

(i.e. 1/10,000th [10-4] of the speed of light)

for expulsion from a heliocentric distance of 1AU (1AU = the mean distance between the Sun and the Earth).

Microorganisms especially viruses and dessicated bacteria, retaining viability thus reach a next neighbouring planetary system from an original point source (e.g., the solar system) in a typical time of 40,000 yr. Since accommodation of such microbes within cometary or other amplification niches in the new system and their exponential replication proceeds on timescales much shorter than 40,000 yr, we can assume that a "wave of colonisation" progresses at an effective speed of approximately $v \approx 3 \times 10^6$ cm/s.

Crossing a typical galactic dimension of 100,000 ly will then be accomplished in a mere 109 yr. In reality, however, the state of readiness of a recipient planetary system to amplify and redistribute iterant microbes must also be taken into account, but the time delays introduced by this refinement are likely to be negligible.

Collision of comets and asteroids onto the surfaces of inhabited planets like the Earth could also result in the ejection and transference of genes belonging to evolved life-forms (e.g., viruses and bacteria) to neighbouring planetary systems. This process will be particularly important when massive molecular clouds with newly formed stars and planets act as perturbing objects that deflect comets from Oort-type comet clouds. On such a picture, Darwinian evolution will not be confined to a single planetary biosphere but would extend across a biosphere embracing the entire galaxy.

These considerations add further to earlier arguments that show astronomical spectroscopic studies of interstellar dust matching the predictions of bacteria and their degradation products, and the putative identification of microfossils in meteorites [5,12].

Finally we turn to arguments from genetics. Extensive studies of the human genome (and other genomes) have shown the presence of viruses (mainly retroviruses) making up a large fraction of inert DNA. This can be interpreted in terms of predictions from the Hoyle-Wickramasinghe theory of evolution from space[13]. These viral sequences are the relic of invasions from space that led to their insertion in our ancestral line, and they serve a positive role as carrying dormant information for further evolution[14].

THOUGHT EXPERIMENT CONCLUSION

That from a single point source of origin the full colonisation of the entire Milky Way galaxy by primitive microbes will take place in a timescale less than the average age of low-mass stars in the galactic disc, 10^{10} yr (i.e., 10 byr). The universe is generally estimated to be 13.8 byr old.

Note: This paper uses the very latest estimates of the number of habitable Earth-like exoplanets in the Milky Way – now estimated (June 2013) at 144 billion.

EVALUATION OF THE THOUGHT EXPERIMENT *Origin of Life in Comets*

Support for the idea that life originated on Earth in a primordial soup is beginning to wear thin in the light of modern geological and astronomical evidence. It is becoming clear that life arose on Earth almost at the very first moment that it could have survived.

During the so-called Hadean Epoch of the Earth, which involved heavy cometary bombardment, there is clear evidence of an excess of the lighter carbon isotope ^{12}C compared with ^{13}C indicating the action of microorganisms that preferentially take up the lighter isotope from the environment[2,21].

The Hadean epoch in the Earth's geological history was undoubtedly marked by an exceptionally high frequency of comet and asteroid impacts. It is generally thought that much of the water in the oceans came from comets. Along with the water, comets also brought life. This is the theory of Cometary Panspermia proposed in 1979 by Hoyle and Wickramasinghe (one of the present writers).

EXPERIMENTS AND EVIDENCE

In the formation of a planetary system such as the solar system (and the proto-planetary galaxy) the first solid objects to form are the comets. These icy objects would contain the molecules of the parent interstellar cloud, and for a few million years after they condensed would have liquid water interiors due to the heating effect of radioactive decays[5].

If microbial life was already present in the parent interstellar cloud, the newly formed comets serve to amplify and promulgate it on a very short timescale.

Evidence is accumulating for the existence of microbes (viruses, bacteria and other yet unidentified biological entities) in a large number of meteoroids collected on the surface of the Earth as well as in the stratosphere[8].

In 2013, further analysis of the Polonnaruwa Meteorite provided strong evidence in the opinion of the writers consistent with the rocks being meteorites[16,17]. Although at the time of writing the Polonnaruwa rocks have not yet been submitted to the Nomenclature Committee of the Meteoritical Society. This is planned for Spring 2014. This submission will need to be successful before the significance of the two papers[18,19] which assess the possible discovery of Fossil diatoms in the rocks, can be assessed.

During 2014, there are two experiments observers can monitor where evidence could be acquired which would be inconsistent with the theory that comets like ISON really do carry the seeds of life. The first is Sheffield University's Professor Milton Wainwright's experiments in the stratosphere in January 2014 looking for viruses and bacteria in the pre-perihelion tail of Comet ISON as the Earth passes close to the trailing particles.

The second is NASA's initiative monitoring ISON from both space (Hubble) and ground based telescopes (ALMA). In particular, we will watch results from the Comet Ison Observing Campaign (CIOC) as the team observes ISON from Earth using the ALMA telescope in Chile. They are experts at remote identification of pre-biotic complex molecules especially those required by RNA/DNA.

2013 saw NASA move its umbrella mission focus from "Search for Water" to the "Difficult Endeavor of Seeking the Signs of Life".

There is debate continued on the evidence in DNA for the extra-terrestrial origin of life [22,23,24].

Finally, the important role of viruses is being recognized. The U.S. Geological Survey confirmed the importance of viruses as the primary driver of evolution on Earth[25]. They stated "Historically, viruses have been mostly ignored in the field of astrobiology due to the view that they are not alive in the classical sense and if encountered would not present risk due to their host-specific nature". They recommended, "that in our quest for extraterrestrial life, we should be looking for viruses; and while any encountered may pose no risk, the possibility of an encounter with a virus capable of accessing multiple cell types exists".**H**

CONFLICTS OF INTEREST Authors declare no conflicts of interest.

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REFERENCES

1 Napier WM. A mechanism for interstellar panspermia. Mon Not R Astron Soc. 2004;348:46-51. http://dx.doi.org/10.1111/j.1365-2966.2004.07287.x

2 Mojzsis SJ, Arrhenius G, McKeegan KD, Harrison TM, Nutman AP, Friend CRL. Evidence for life on Earth before 3,800 million years ago. Nature. 1996;384:55-59. http://dx.doi.org/10.1038/384055a0 PMid:8900275

3 Schmitt-Kopplin P, Gabelica Z, Gougeon RD, Fekete A, Kanawati B, Harir M, et al. High molecular diversity of extraterrestrial organic matter in Murchison meteorite revealed 40 years after its fall. PNAS. 2010;107:2763-2768. http://dx.doi.org/10.1073/pnas.0912157107 PMid:20160129 PMCid:PMC2840304

4 Deamer D. First Life: Discovering the connections between stars, cells, and how life began. Los Angeles, California: University of California Press; 2011.

5 Wickramasinghe JT, Wickramasinghe NC, Napier WM. Comets and the origin of life. Singapore: World Scientific; 2010.

6 Wallis MK, Wickramasinghe NC. Interstellar transfer of planetary microbiota. Mon Not R Astron Soc. 2004;348, 52-57. http://dx.doi.org/10.1111/j.1365-2966.2004.07355.x

7 Belbruno E, Moro-Martin A, Malhotra R, Savransky D. Chaotic exchange of solid material between planetary systems: Implications for lithopanspermia. Astrobiol. 2012;12:754-74. http://dx.doi.org/10.1089/ast.2012.0825 PMid:22897115 PMCid:PMC3440031

8 Smith WE. 2013 – Life is a cosmic phenomenon: The "Search for Water" evolves into the "Search for Life". Proc SPIE. 2013;8865:88650Q. http://dx.doi.org/10.1117/12.2046862

9 Kopparapu RK, Ramirez R, Kasting JF, Eymet V, Robinson TD, Mahadevan S, et al..Habitable zones around main sequence stars: New estimates 2013. Astrophys J. 2013;765:1-16. http://dx.doi.org/10.1088/0004-637X/765/2/131

10 Hoyle F, Wickramasinghe NC. Astronomical origins of life. Dordrech: Kluwer; 2000. http://dx.doi.org/10.1007/978-94-011-4297-7

11 Wickramasinghe NC. The astrobiological case for our cosmic ancestry. Int J Astrobiol. 1973; 9:119-29. http://dx.doi.org/10.1017/S1473550409990413

12 Wickramasinghe NC. Bacterial morphologies supporting cometary panspermia: A reappraisal. Int J Astrobiol. 2011;10:25-30. http://dx.doi.org/10.1017/S1473550410000157

13 Hoyle F, Wickramasinghe NC. Evolution from space. London: J.M. Dent; 1980.

14 Wickramasinghe NC. DNA sequencing and predictions of the cosmic theory of life. Astrophys Space Sci. 2012;343:1-5. http://dx.doi.org/10.1007/s10509-012-1227-y

15 Manning CE, Mojzsis SJ, Harrison TM. Geology, age and origin of supracrustal rocks at Akilia, West Greenland. Am J Sci. 2006;306:303-66. http://dx.doi.org/10.2475/05.2006.02

16 Wallis J, Miyake N, Hoover RB, Oldroyd A, Wallis DH, Samaranayake K, et al. The Polonnaruwa meteorite: Oxygen isotope, crystalline and biological composition. J Cosmol, 2013;22(2).

17 Wallis J, Wickramasinghe NC, Wallis DH, Miyake N, Wallis MK, Hoover RB, et al. Physical, chemical, and mineral properties of the Polonnaruwa stones. Proc SPIE. 2013;8865:886508. http://dx.doi.org/10.1117/12.2029607

18 Wickramasinghe NC, Wallis J, Wallis DH, Samaranayake, A. Fossil diatoms in a new carbonaceous meteorite. J Cosmol. 2013;21:1-14.

19 Wainwright M, Rose CE, Baker AJ, Briston KJ, Wickramasinghe NC. Typical meteoritic worm-like forms seen in the Polonnaruwa Meteorite. J Cosmol. 2013;22:10152-10157.

20 Joseph R, Wickramasinghe NC. Genetics indicates extraterrestrial origins for life: The first gene. Did life begin following the Big Bang? J Cosmol. 2011;16:6832-6861.

21 Mojzsis SJ, Harrison TM, Pidgeon RT. Oxygen-isotope evidence from ancient zircons for liquid water at the Earth's surface 4,300 Myr ago. Nature. 2001;409:178-81. http://dx.doi.org/10.1038/35051557 PMid:11196638

22 Sharov AA. Exponential increase of genetic complexity supports extra-terrestrial origin of life. J Cosmol. 2009; 1:63-65.

23 Sharov AA. Genetic gradualism and the extra terrestrial origin of life. J Cosmo. 2010;5:833-42.

24 Sharov AA, Gordon RB..Life Before Earth. 2013 arXiv:1304.3381.

25 Griffin DW. The quest for extraterrestrial life: What about the viruses. Astrobiol. 2013:774-83. PMid:23944293