An Update on Panspermia

John Lattanzio

But mostly:

Chandra Wickramasinghe

Dayal Wickramasinghe

Christopher Tout
WARNING!

- I am not going to show you the proverbial smoking gun!

- “Oh wow! That nails it!” (crossed out)

- Maybe: “Hmmm. That is interesting.”
A Long History

- Aristarchus of Samos, 5th Century BC
- Lord Kelvin
  - 1871 address to British society for Advancement of Science
- Arrhenius coined the word "panspermia" in 1908
  - Often taken as the "father of the field"
- Other supporters:
  - Francis Crick, Freeman Dyson, Richard Dawkins, Stephen Hawking
- Modern Reincarnation
  - Fred Hoyle and Chandra Wickramasinghe
  - 1970s and 80s

Appeal to authority is not a good scientific argument...!
History

• Weak Panspermia
  – Organic material delivered from space
  – Now accepted and not controversial

• Strong panspermia
  – Actual biological entities delivered from space
  – Not accepted and very controversial

• Directed Panspermia
  – Deliberate seeding by an intelligent entity

I won’t discuss this!
What is Panspermia?

- Biological things arrived from space
  - Dust, comets

  "Does not explain the origin, just displaces it!"
  - So what?
    - Knowing it did not arise here would be an important discovery!

- No direct evidence for Earth-based abiogenesis...
2. Plausibility: Carts and Horses

- Astrology and AAS
  - There is no way planets can affect lives.
  - Astrology is rubbish!
  - Newspapers should print “for entertainment only” disclaimers

- But...

- “Rocks fall from the sky”
  - Science: “No they don’t…”
  - Well, it turns out that they do...
Carts and Horses

- Good science does not say “There is no mechanism for this.”
- Hence “It is impossible.”
- Good science says: “Is there a phenomenon to explain?”
- If so: then we do need to find a mechanism.
- If not: then we do not need to find a mechanism.
- That has the horse before the cart...
PART 3:

Status of the Original Arguments
Galactic Extinction: Infrared and the 3.4\(\mu\) feature

Hoyle & C. Wickramasinghe 1979
Allen & D. Wickramasinghe 1979
NEAR-INFRARED ABSORPTION SPECTROSCOPY OF INTERSTELLAR HYDROCARBON GRAINS

Y. J. Pendleton,¹ S. A. Sandford,²,³ L. J. Allamandola,²,³ A. G. G. M. Tielens,¹ and K. Sellgren³,⁴,⁵

Murchison fits well!
Near-Infrared Absorption Spectroscopy of Interstellar Hydrocarbon Grains


Probably due to CH bonds...

Not necessarily biology
Galactic Extinction: Infrared and the 3.4µ feature

- Spectrum now seen by many authors

Six lines of sight
Galactic Extinction: Infrared and the 3.4\,\mu\,m feature

- Spectrum now seen by many authors

CH aromatics  Different CH modes  Six lines of sight
PART 4:

Recent Developments
Comets as a Source of Microbiota

- "They are too cold (at aphelion, at least!)"
  - Radiogenic heating is significant


Thermal evolution of cometary nuclei by radioactive heating and possible formation of organic chemicals

S. Yabushita

- Liquid interior for comets with radii > 200km
- At all distances from the Sun...
- Bacteria reproduce quickly under the right conditions...
STARDUST recovery mission

- Lots of organics
- Glycine! (Simplest amino acid.)
- No clear biological specimens...

Cometary glycine detected in samples returned by Stardust

Jamie E. ELSILA*, Daniel P. GLAVIN, and Jason P. DWORKIN
The organic-rich surface of comet 67P/Churyumov-Gerasimenko as seen by VIRTIS/Rosetta

Hi-Res spectrum of comet

Dessicated E coli
Molecular Oxygen: $O_2$

- Oxygen - made by cyanobacteria (and from dissociation of water...)
- Detected with water and other organics by Rosetta
- ...discovered $O_2$ and $O_3$ and methanol...
- These cannot co-exist in equilibrium together
- Consistent with biological processes.
Phosphorous?

- P is present in ATP and hence RNA and DNA
- Measured P/C $\approx 10^{-2}$
- Solar system value P/C $\approx 10^{-3}$
- Further, expect some P to be lost to refractory minerals...
- Consistent with biological processes and concentration mechanisms
Methyl Chloride: \( \text{CH}_3\text{Cl} \)

- Made biologically on Earth
  - By microalgae in oceans, with or without light
  - Produced by decay of wood rotting fungi
- Has been suggested as a bio-marker
  - Search for it in planetary atmospheres
  - Indicates existence of life
- Seen in comet 67P/C-G (by Rosetta)
  - “Need to find an abiological production mechanism.”
  - No wonder the proponents get frustrated 😞
Ethyl Alcohol

- First detection of ethanol in a comet
- First detection of a sugar in a comet
  - Emitting equivalent of 500 bottles of wine per second 😊
  - And it should be stopped!
- Simplest monosaccharide glycoaldehyde $\text{CH}_2\text{OHCHO}$
- Of course bacteria produce ethanol from sugars...
Comets as a Source of Microbiota

- The evidence is consistent with the hypothesis
- The evidence is not compelling, however...
Micro-fossils in meteorites?
Microstructure and elemental composition of the Tagish Lake meteorite and its astrobiological implications

Kani Rauf¹, Anthony Hann² and Chandra Wickramasinghe¹

Fig. 1. Scanning electron microscopy images of Tagish Lake. (a) A fragment of Tagish Lake. (b) Plaquettes of crystallized minerals. (c) Chunks of minerals showing a concentric and layered structure. (d) A group of hexagonal bodies, some of which appear almost spherical. (e) Plaquettes of crystallized minerals partially integrated into the matrix. (f) High magnification of hexagonal bodies showing a smooth surface, suggestive of metal alloys.
Bacterial morphologies in carbonaceous meteorites and comet dust
Chandra Wickramasinghe*, Max K. Wallis®, Carl H. Gibson®, Jamie Wallis®, Shirwan Al-Mufti® and Nori Miyake®

*Article in Proceedings of SPIE - The International Society for Optical Engineering - August 2010
Two of these are cyanobacteria.

Two are structures found inside the Murchison meteorite.

*Can you tell which is which?*
These two are cyanobacteria.

These two are structures found in the Murchison meteorite.
At last – something not controversial!

Carbonaceous meteorites contain a wide range of extraterrestrial nucleobases

Michael P. Callahan1, Karen E. Smith2, H. James Cleaves III, Josef Ruzicka3, Jennifer C. Stern4, Daniel P. Glavin5, Christopher H. House6, and Jason P. Dworkin4

1National Aeronautics and Space Administration Goddard Space Flight Center and The Goddard Center for Astrobiology, Greenbelt, MD 20771; 2Department of Geosciences and Penn State Astrobiology Research Center, Pennsylvania State University, 220 Deike Building, University Park, PA 16802; 3Geophysical Laboratory, Carnegie Institution of Washington, Washington, DC 20015; and 4Scientific Instruments Division, Thermo Fisher Scientific, Somerset, NJ 08872

All terrestrial organisms depend on nucleic acids (RNA and DNA), which use pyrimidine and purine nucleobases to encode genetic information. Carbon-rich meteorites may have important sources of organic compounds required for the emergence of life on the early Earth; however, the origin and formation of nucleobases in meteorites has been debated for over 50 y. So far, the few nucleobases reported in meteorites are biologically common and lack the structural diversity typical of other indigenous meteoritic organics. Here, we investigated the abundance and distribution of nucleobases and nucleobase analogs in formic acid extracts of 12 different meteorites by liquid chromatography-mass spectrometry. The Murchison and Lonewolf Nunataks 94102 meteorites contained a diverse suite of nucleobases, which included three unusual and terrestrially rare nucleobase analogs: purine, 2,6-diaminopurine, and 6,8-diaminopurine. In a parallel experiment, we found an identical suite of nucleobases and nucleobase analogs generated in reactions of ammonium cyanide. Additionally, these nucleobase analogs were not detected above our parts-per-billion detection limits in any of the procedural blanks, control samples, a terrestrial soil sample, and an Antarctic ice sample. Our results demonstrate that the purines detected in meteorites are consistent with products of ammonium cyanide chemistry, which provides a plausible mechanism for their synthesis in the asteroid parent bodies, and strongly supports an extraterrestrial origin. The discovery of new nucleobase analogs in meteorites also expands the prebiotic molecular inventory available for constructing the first genetic molecules.

The Murchison and Lonewolf Nunataks 94102 meteorites contained a diverse suite of nucleobases, which included three unusual and terrestrially rare nucleobase analogs:
A new family of extraterrestrial amino acids in the Murchison meteorite

Toshiki Koga¹ & Hiroshi Naraoka¹²

The occurrence of extraterrestrial organic compounds is a key for understanding prebiotic organic synthesis in the universe. In particular, amino acids have been studied in carbonaceous meteorites for almost 50 years. Here we report ten new amino acids identified in the Murchison meteorite, including a new family of nine hydroxy amino acids. The discovery of mostly C₃ and C₄ structural isomers of hydroxy amino acids provides insight into the mechanisms of extraterrestrial synthesis of organic compounds. A complementary experiment suggests that these compounds could be produced from aldehydes and ammonia on the meteorite parent body. This study indicates that the meteoritic amino acids could be synthesized by mechanisms in addition to the Strecker reaction, which has been proposed to be the main synthetic pathway to produce amino acids.
Space Hardiness of Microbes

- We used to think they could not survive in space
- Direct evidence now contradicts this
  - There are many cryophilic organisms
  - Many can survive multiple freeze-thaw cycles

Metabolism seen at -20°C in some psychrophilic bacteria
Can bacteria survive impacts?

Small but finite survival fraction. That is all they need. They reproduce very quickly.

**Survival of bacteria and spores under extreme shock pressures**

M. J. Burchell, J. R. Mann and A. W. Bunch

1 Centre for Astrophy Physics and Planetary Sciences, University of Kent at Canterbury, Canterbury, Kent CT2 7NT
2 School of Biosciences, University of Kent at Canterbury, Canterbury, Kent CT2 7NF

Figure 1. Survival rate for impacts of *Rhodococcus erythropolis* on agar targets.
UV threat to microbes?

LIFE Experiment: Isolation of Cryptoendolthic Organisms from Antarctic Colonized Sandstone Exposed to Space and Simulated Mars Conditions on the International Space Station

Authors

Giuliano Scalzi, Laura Selbmann, Laura Zucconi, Elke Rabbow, Gerda Horneck, Patrizia Albertano, Silvano Onofri
Abstract

Desiccated Antarctic rocks colonized by cryptoendolithic communities were exposed on the International Space Station (ISS) to space and simulated Mars conditions (LiFE—Lichens and Fungi Experiment). After 1.5 years in space samples were retrieved, rehydrated and spread on different culture media. Colonies of a green alga and a pink-coloured fungus developed on Malt-Agar medium; they were isolated from a sample exposed to simulated Mars conditions beneath a 0.1 % T Suprasil neutral density filter and from a sample exposed to space vacuum without solar radiation exposure, respectively. None of the other flight samples showed any growth after incubation. The two organisms able to grow were identified at genus level by Small SubUnit (SSU) and Internal Transcribed Spacer (ITS) rDNA sequencing as Stichococcus sp. (green alga) and Acarospora sp. (lichenized fungal genus) respectively. The data in the present study provide experimental information on the possibility of eukaryotic life transfer from one planet to another by means of rocks and of survival in Mars environment.
Survival of Bacteria in space? For long periods?

**Isolation of a 250 million-year-old halotolerant bacterium from a primary salt crystal**

Russell H. Vreeland*, William D. Rosenzweig* & Dennis W. Powers†

Bacteria have been found associated with a variety of ancient samples, however few studies are generally accepted due to questions about sample quality and contamination. When Cano and Borucki isolated a strain of *Bacillus sphaericus* from an extinct bee trapped in 25–30 million-year-old amber, careful sample selection and stringent sterilization techniques were the keys to acceptance. Here we report the isolation and growth of a previously unrecognized spore-forming bacterium (Bacillus species, designated 2-9-3) from a brine inclusion within a 250 million-year-old salt crystal from the Permian Salado Formation. Complete gene sequences of the 16S ribosomal DNA show that the organism is part of the lineage of *Bacillus marismortui* and *Virgibacillus pantothenticus*. Delicate crystal structures and sedi-
Research Article

The DNA of Bacteria of the World Ocean and the Earth in Cosmic Dust at the International Space Station


1Federal Research Center of Epidemiology and Microbiology named afterGamalei, Moscow, Russia
2Peoples Friendship University of Russia (RUDN University), 6 Miklukho-Maklaya St, Moscow 117198, Russia
3Central Research Institute of Machine Building, Korolev, Russia
4Dumanskii Institute of Colloid and Water Chemistry, National Academy ofSciences of Ukraine, Kiev, Ukraine
5Korolev Rocket and Space Corporation «Energia», Korolev, Russia
Cosmic dust samples from the surface of the illuminator of the International Space Station (ISS) were collected by a crew member during his spacewalk. The sampler with tampon in a vacuum container was delivered to the Earth. Washouts from the tampon's material and the tampon itself were analyzed for the presence of bacterial DNA by the method of nested PCR with primers specific to DNA of the genus *Mycobacteria*, DNA of the strains of capsular bacteria *Bacillus*, and DNA encoding 16S ribosomal RNA. The results of amplification followed by sequencing and phylogenetic analysis indicated the presence of the bacteria of the genus *Mycobacteria* and the extreme bacterium of the genus *Delftia* in the samples of cosmic dust. It was shown that the DNA sequence of one of the bacteria of the genus *Mycobacteria* was genetically similar to that previously observed in superficial micro layer at the Barents and Kara seas' coastal zones. The presence of the wild land and marine bacteria DNA on the ISS suggests their possible transfer from the stratosphere into the ionosphere with the ascending branch of the global electric circuit. Alternatively, the wild land and marine bacteria as well as the ISS bacteria may all have an ultimate space origin.
“It must be contamination...”

- Control samples were negative
- DNA was found in 10 different samples
- Samples were collected over 4 years

- They were **ALL** contaminated?
- But **NONE** of the controls were?

That seems very unlikely...
"It must be transported from Earth..."

- 400km?
- Stratosphere (40km): sure
- No known mechanism can get to 330 - 430km

Maybe it was lifted...

But note: It is exactly what is predicted...
Catch-22

- If we find DNA or Earth microbes?
  - "It's contamination!"
  - But if it's not, it is exactly what panspermia predicts!
  - How to tell???
A Falsification Prediction

- On the other hand...
- If we discover life with a radically different biochemistry to that found on Earth...
  - Then that would rule out panspermia
5. Conclusions and Summary

The strength of the claim of cosmic biology derives it being a minimal hypothesis that is able to explain an extraordinarily diverse set of data.

There is no smoking gun.

But that is also true for the alternative theory of Earth-based abiogenesis!

Do not forget this!
5. Conclusions and Summary

Both sides need a smoking gun 😊

Which is the simpler hypothesis?

Abiogenesis on Earth?
Abiogenesis elsewhere with spreading?

On Earth 99.999% of organics come from biology

Is it really likely to be 0% in space?
“When a result is culturally unacceptable it will always be discounted on some excuse or other.”

F. Hoyle & C. Wickramasinghe 1986 Nature 332, 509

“In the Solar System, almost all biologically relevant molecules can be found in the soluble component of carbonaceous meteorites.”

Sun Kwok, A+ARev, 2016, 24:8
Chandra Wickramasinghe:

“If there is anything worth respecting in the conventional argument of essentially instant abiogenesis on Earth in a small pond (or hydrothermal vent) in a vanishingly small slice of geological time, then this process would have been detected in the laboratory by now...”
5. Conclusions and Summary

- Isaac Asimov:
  - The most exciting phrase to hear in science, the one that heralds new discoveries, is not ‘Eureka!’ but is rather ‘That’s odd…’

- Nothing I have told you is compelling evidence for panspermia

- But...there are some odd coincidences that we should consider...
The End.....?

Well, no it's not. Surely there will be more...