Notes on Quasicrystals and the Origin of Life

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Abstract

We still do not understand the origins of life. Here I suggest that it may have arisen as a fractal quasicrystal of organic molecules on a metallic quasicrystalline template. It may have arisen at least twice, once with pentagonal symmetry and once with octagonal symmetry. In both instances these protolife forms are part of an imperfect fractal continuum from the subatomic to the galactic.

Key Words: Quasicrystals, Origin of Life, Grand Unifying Theory (GUT).

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Introduction

"It is more important to have beauty in one's equations than to have them fit experiment." Paul Dirac.

This paper was written on the land of the Gadigal People of the Eora Nation. I acknowledge sovereignty was never ceded and pay respect to past, present and emerging elders.

Below I discuss the possibility that life began as organic molecules forming quasicrystals on a metallic template. It seems likely that this occurred at least twice, once with pentagonal quasisymmetry and once with octagonal quasisymmetry. These quasicrystalline composites stand partway between the subatomic, and the living beings that have evolved from these beginnings. They hint at a perfection which remains elusive.

Fractals

All major religions feature fractals as part of their iconography. Hindu temples are made from fractal blueprints which determine the final appearance of the temple. Early Christian art made use of the Sierpinski triangle, a fractal formally identified centuries later. Australian Aboriginal art uses fractals to depict water management. Islamic gardens created before the European Renaissance are fractal (Patuano and Lima 2021). Buddhist Shaolin monks practice martial arts which are an extension of underlying fractal tensegrity architecture in the body and mind.

Fractals are mathematical constructs which are self-similar at different scales. The Universe is nearly fractal from subatomic particles to superclusters of galaxies. Nearly. This might be interpreted as the Universe being not quite perfect. Which of, as human beings, we are well aware. It is said Buddha met with enlightened beings from other world systems who were astounded by the degeneracy of Earth. "Yes but how much more meritorious is a good act in such a degenerate realm" replied Buddha. Herein I suggest that life may be the result of fractal processes operating through naturally occurring quasicrystals.

What is a Quasicrystal?

A crystal is a solid with a regular ordering of atoms which forms a lattice that extends in all directions. A quasicrystal has a structure which is ordered but not periodic. Thus it has a symmetry for which no regular tiling can exist. That is 5,7,8, etc.

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A number of aperiodic tilings discovered by mathematicians have been found to describe the structure of quasicrystals. For example the Penrose tiling with a periodicity of 5 and the Ammann-Beenker tiling with a periodicity of 8. Quasicrystals can also be understood as the projection of a higher-dimensional "parent" crystal onto lower dimensional space (Gardiner et al. 2010; Santos 2019).

Do Quasicrystals Occur at Subatomic Level?

The Grand Unifying Theory (GUT) aims to show that when quarks, which are bound together by the strong nuclear force, and leptons which are fermions coupled to the electromagnetic field and/or weak nuclear force, are less than 10^{-31}m apart they can interconvert. When further apart they "break symmetry". This was confirmed for the electroweak theory, whereby the electromagnetic and weak nuclear forces are fundamentally the same, with the discovery of the Higgs Boson. Still, despite best efforts, a GUT has yet to be proven and a change of focus is perhaps required, with a different view of symmetry.

Maybe this is how: the discovery of quasicrystals has rewritten a large chunk of crystallography. Order was thought associated with spontaneous symmetry breaking with the less ordered phase possessing a higher degree of symmetry. Quasicrystals are the physical manifestation of aperiodic mathematical tilings. They possess no rotational or translational symmetry but does this mean they have no symmetry at all (Lifshitz 2011)? Indeed lepton-quark families manipulated geometrically have mathematics similar to Penrose aperiodic tilings (Koca et al., 2018). This shows that while perhaps not symmetrical as such a GUT may need to rely upon quasisymmetry to describe the subatomic.

Pentagonal Biological Quasicrystals

Both plant endoplasmic reticulum in fertilised generative cells and neurotransmitter complex proteins in animals are pentagonal quasicrystals. As such, in both plants and animal nervous systems, there are abundant examples of the mathematical golden mean which is associated with pentagonal geometry. Pentacene organic molecules absorbed on quasicrystal surfaces exhibit quasicrystalline order as do C_{60} molecules (Sharma et al. 2022: Figure 1). This makes them fractal and also suggests that an adsorption of organic molecules to metallic quasicrystalline surfaces is a plausible hypothesis for the formation of the first polypeptides. Amino acids, present in the primordial oceans, adhere to quasicrystals faster than to regular alloys (Lefaix et al. 2007) so this is a distinct possibility.

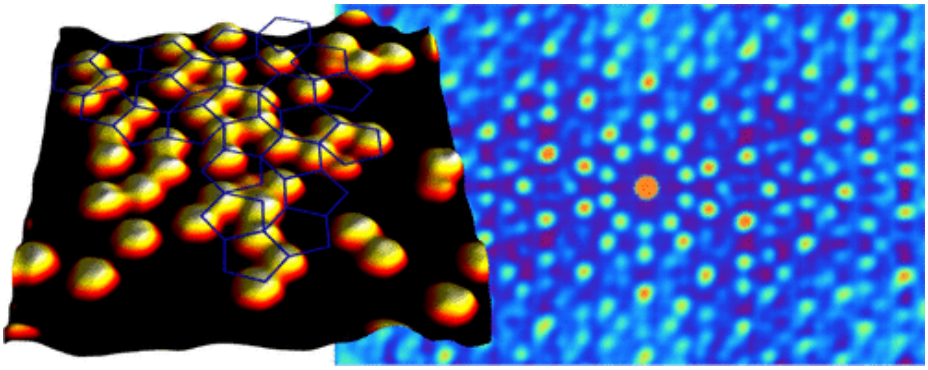

Figure 1. C_{60} (left) and pentacene (right) adsorbed onto metallic quasicrystalline templates. In both instances quasicrystal fractals are formed with a 5-fold pentagonal symmetry (C_{60}) and decagonal symmetry (pentacene). Reprinted (adapted) with permission from: Smerdon JA, Young KM, Lowe M, Hars SS, Yadav TP, Hesp D, Dhanak VR, Tsai AP, Sharma HR, McGrath R. Templated quasicrystalline molecular ordering. Nano Letters 2014; 14: 1184-1189. Copyright 2014 American Chemical Society

The only natural metallic quasicrystals to be discovered have been found in a Siberian meteorite. It has been shown that quasicrystals can be formed when suitable substrates are smashed together at high velocity. Thus it seems likely that the Siberian quasicrystals were formed when two asteroids impacted and subsequently fell to Earth although their genesis does predate the formation of the Solar System. It has been proposed that crystals were the substrate for the formation of the first life. Maybe these extra-terrestrial quasicrystals were the template?

Octagonal Biological Quasicrystals

Octagonal quasicrystals can be seen in subcellular nuclear pore complexes.

It is worthwhile here considering Australian Aboriginal religions. The cultures revere the state of things, as they are found, and how this leads to survival. Geology uses fractals to describe landscapes and Australian Aboriginal culture is at the point where initiates ARE the fractal landscape, weather and other living beings. For something to exist within Aboriginal culture it must be present in the physical or metaphysical world. This encompasses both contemporary and more traditional Dreamings.

Recently collaboration between Johnson Tiles and Bay Gallery Home of the UK with Geraldine Nangala Gallagher of Yuendumu in Australia has focussed on a work depicting an Emu Dreaming (Figure 2). In fact it is the story of the Emu and Bustard fighting over bush raisins. The work has an 8-fold symmetry, one which must be aperiodic and thus points to the presence of this quasicrystalline state in the Nation of the artist. Interestingly the silver mean (2.414…) which is a number associated with octagonal geometry, crops up when the food preferences of aphids are examined (Ninkovic et al. 2013). Thus the presence of octagonal quasicrystals is fractal and extends through the various trophic levels of biology.

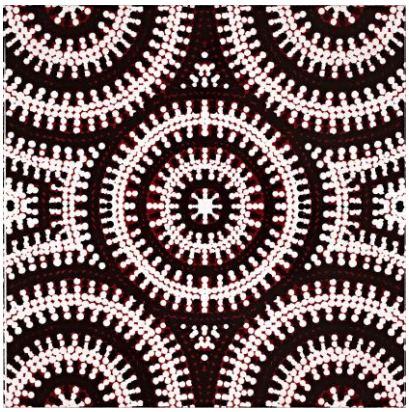

Figure 2. Emu Dreaming by Johnson Tiles and Bay Gallery Home of the UK with Geraldine Nangala Gallagher of Yuendumu, Australia. Note octagonal symmetry of the design

Octagonal Quasicrystals and Life

Block copolymers, of which amino acid chains are an example, showed octagonal symmetry by Fast Fourier Transform when decorating Ammann-Beenker substrates (Ding et al. 2019). Indeed investigation into synthetic amino acid-based block polymers gives insight into order and function which can be programmed into peptide blocks (Rabotyagova et al. 2011). No natural metallic quasicrystals with octagonal symmetry have been discovered. However, metallic inclusions in diamonds from the Tolbachik volcano have a composition similar to that of artificial octagonal quasicrystals. So their existence is certainly not out of the question (Bindi et al. 2020).

Concluding Remarks

Many ideas that are likely to be important in our understanding of life, where it started, what does it mean, have been recently put on the table. Quasicrystals, fractals, Grand Unifying Theories. We may never know definitively what took place indeed this approaches the realm of religions and it is important to give these traditions the respect they deserve. Nonetheless it IS good to cogitate on these matters. A pleasant and productive way to pass some time.

The author declares no conflict of interest.

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