POST-BIOLOGY vs PRE-BIOLOGY:

Correspondence between

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A paper published in *Nature* entitled "Mixed aromatic–aliphatic organic nanoparticles as carriers of unidentified infrared emission features" by Sun Kwok & Yong Zhang (*Nature*, **470**, 80, 2011) generated the following responses and correspondence between S. Kwok and N.C. Wickramasinghe. *Nature* decided against publishing this material due to pressure of space. However, in view of the scientific interest of the arguments contained in the correspondence, this material is published below:

THE ORIGIN OF AROMATIC-ALIPHATIC ORGANIC NANOPARTICLES IN INTERSTELLAR CLOUDS

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In a recent letter Kwok and Zhang[1] have proposed that a set of unidentified interstellar emission bands at infrared wavelengths may arise from mixed aromatic-aliphatic organic structures. The proposal extends and corroborates earlier studies published in the columns of this journal over a period spanning nearly 4 decades. Theoretical impediments to understanding how such structures form may be eased if they can be assumed to arise from the break-up of larger organic grains of possible biologenic origin.

The first proposal of organic polymer grains in the interstellar medium was made by the present writer who suggested that formaldehyde polymers might explain the 8-14μm emission spectrum of dust in the Trapezium nebula[2]. With rapid advances in the techniques of infrared astronomy through the 1970's the constraints on permissible polymer models of interstellar dust became ever more stringent. There followed a series of comparisons of astronomical infrared spectra of improved quality with the behaviour of aromatic-aliphatic complexes of various kinds – sporopollenin[3], polysaccharides[4,5] and polyaromatic hydrocarbons[6]. Hoyle and the present writer first proposed bicyclic aromatic hydrocarbons as carriers of the λ2175A interstellar extinction band, offering a better model for this feature than the widely favoured graphite hypothesis[6,7].

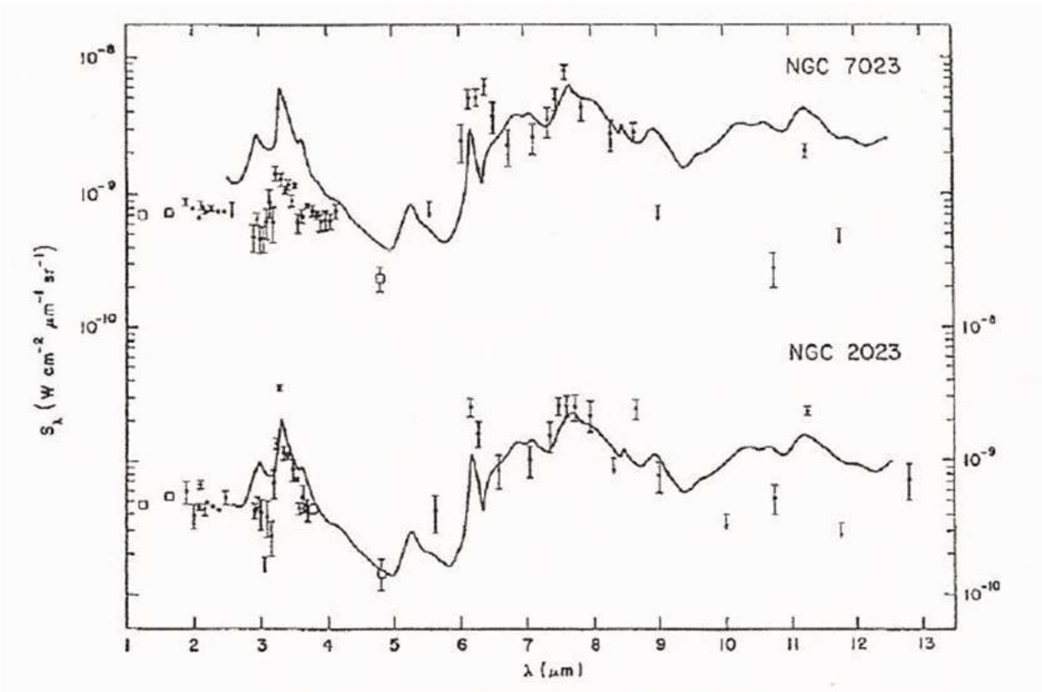
By the early 1980's there was ample evidence for a wide range of complex organic molecular structures being present in the interstellar medium with a possible relevance to biology, but the mechanisms for their formation remained far from clear. Whilst small, low molecular weight organic molecules may have formed by well understood gas phase processes, the larger molecules posed a challenge to theorists.

The widespread occurrence of interstellar emission features in a variety of galactic sources at ~ 3.28μm, 6.2 μm, 7.7 μm, 8.6 μm, 11.3 μm and other wavelengths had been known from the early 1980's. To explore the hypothesis that these may arise from the degradation products of biology we averaged the emissivities of 115 naturally occurring aromatic-aliphatic complexes including α,β unsaturated acides, esters and lactones, pyridines, quinolines, purines and other molecules. We assumed an equimolar mix of the molecules distributed uniformly within nanoparticles that took up temperatures in the range 1200 – 200K (ref 7.8).

Fig. 1 shows the normalised emission from the ensemble of 115 molecules compared with the data for the earliest infrared data available in 1989 for the two sources NGC7023 and NGC2023 (ref.8). More recent data of much higher quality (eg the Spitzer telescope spectra) are generally consistent with the ensemble average, with principal emission band comparisons listed in the Table in the bottom of Fig.1. In a more recent study extracts of grasses, algae, anthracite and coal were shown to have similar absorption features to our ensemble of 115 molecules – all of which are also consistent with the spectra of Kwok and Zhang[1].

It was also shown that the same mixture of molecules giving rise to the flux curves of Fig.1 could account for the interstellar absorption band centred at 2175A (ref.7), indicating that the radiation absorbed in this band by aromatic/aliphatic molecules are effectively re-emitted as the UIE features discussed by Kwok and Zhang[1].

We can estimate that the fraction of interstellar carbon tied up in the form of complex molecular structures amounts to no less than 10% of the total. Two options are available to explain the data: (1) the inferred structures must form abiotically against the odds, possibly in mass flows from evolved stars; (2) they result naturally from the inevitable break-up and degradation of biological grains. Option (2), whilst being unorthodox according to the reigning paradigms, has the evidence on its side and cannot on logical grounds alone be ruled out.



Wavelength of principal absorption peaks (μm)

NGC 7027, NGC 2023		3.3	3.4		6.2	7.7	8.6	11.3
Mixture of aromatics	2.9	3.3	3.4	5.25	6.2	7.7	8.8	11.3

Fig. 1. The spectra of NGC2023 compared to model involving 115 naturally occurring aromatic complexes (ref.7,8)

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Comments on the Letter "The origin of aromatic-alphatic organic nanoparticles in interstellar clouds" by N.C. Wickramasinghe

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This letter suggests that the mixed aromatic-aliphatic compounds proposed by Kwok & Zhang (2011) as carriers of the unidentified infrared emission (UIE) features are the result of degradation products of biology. From spectroscopic observations of evolved stars, we found a continued progression from simple organic molecules such as acetylene to diactylene, triacetylene, to benzene, and then to aromatic compounds with aliphatic side groups (Kwok 2004, *Nature*, **430**, 985). This pathway of chemical synthesis is observed to follow the stellar evolution sequence from asymptotic giant branch stars to proto-planetary nebulae to planetary nebulae. It is therefore likely that in evolved stars, the synthesis is from simple to complex, not the other way around.

I also wish to note that the UIE features are observed in galaxies with redshift of ~2. According to our present ideas of biological evolution, there would not be enough time for biological system to develop after the first formation of stars after the Big Bang. It is therefore safe to conclude that at least some of the UIE features have an abiological origin.

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December 2011

Comments on Kwok's Response

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Organic molecules like the polyacetylenes, observed in carbon stars were predicted to form in giant stellar atmospheres under near thermodynamic conditions (Tsuji[1]). The expulsion of such molecules, along with graphite particles and graphite precursors, had also been predicted many years ago (Hoyle and Wickramasinghe[2]; Donn et al[3]; Donn[4]). In his response Kwok[5] seeks to connect organic molecules produced in carbon stars with the far more complex molecules associated with the Unidentified Infrared Bands (UIB's) in planetary nebulae and protoplanetary nebulae. The case for an evolutionary connection through this sequence of astronomical objects is weak, however.

The decreasing photospheric temperature along the asymptotic giant branch of the H-R diagram can explain a modest development in complexity from acetylene to triacetylene, for example[5]. But the transition to much larger aromatic-aliphatic complexes[6] and biopolymers or pseudo-biopolymers cannot be easily explained. Dust particles expelled by radiation pressure from giant stars could reach speeds of ~ 10^3 km/s and their impact on the surrounding interstellar medium could naturally lead to break-up of pre-existing larger structures.

Finally, it should be stressed that the argument that UIB's observed in high red-shift galaxies ($z>2$) militates against a biogenic origin is insecure. How much time is indeed required for abiogenesis after the chemical elements of life were synthesised in stars? Gibson et al[7] have argued a case for abiogenesis in $\sim 10^{80}$ warm primordial planets taking place within the first 10 million years after the Big Bang; and there is a wide range of other possibilities.

To conclude: fragmentation of biomaterial remains a viable option for the origin of the UIB carriers and hence for complex organic molecules at very high redshifts.

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22 December 2011

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