NO VALID EVIDENCE EXISTS FOR INTERSTELLAR PROTEINS, BACTERIA, etc.

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ABSTRACT. The claims for large biological molecules and for prokaryotic and eukaryotic organisms in the interstellar medium are summarized. These claims are compared with new UV laboratory spectra of numerous specimens. The results are incompatible with these claims.

Despite the recent contention of Karim, Hoyle & Wickramasinghe[1], it is clear that these authors have not rebutted the criticisms of Savage & Sitko[2] and McLachlan & Nandy[3] on the basis of data quality. The relevant interval of the Long Wavelength Redundant Detector (LWR) spectral coverage from the International Ultraviolet Explorer Spacecraft (IUE) is saturated on the images chosen by Karim, Hoyle & Wickramasinghe[1,4] and no line or band absorptions can be recovered from it. Thus, these images are irrelevant to the question of whether there exist interstellar organisms or the macromolecules, such as proteins and nucleic acids, which might be expected to be associated with such organisms.

This paper shows (a) that such molecules have well-ordered spectral signatures; (b) that caution must be observed in interpreting these signatures; (c) that the spectra of terrestrial organisms are not those which Karim, Hoyle & Wickramasinghe[1] derived from the data they chose.

It is well known that the visible, infrared and radio line and band spectra of interstellar clouds have been interpreted to show the presence of about 60 small organic molecules[5]. For many years now in numerous papers and books Hoyle, Wickramasinghe and several of their colleagues have used some of these spectral details to claim that much more complicated molecules also exist in space. They have firmly asserted the presence of polysaccharides[6] and even viruses[7], bacteria[7], algae[8], diatoms[9], yeasts[10] and other eukaryotic cells[11-13] associated with, or mainly composing interstellar grains. More recently they used the results of the ultraviolet radiation spectroscopy carried out by IUE to compare reddened program stars with reference stars. This led to their claim of a hitherto unrecognized absorption band from 310 to 180 nm[4]. After removing a calculated band due to graphite spheres (0.02μm radius) from the difference spectra, they said the residual peak at 280 nm was almost exactly like that of tryptophan and that this confirmed the presence of

M. D. Papagiannis (ed.), The Search for Extraterrestrial Life: Recent Developments, 165–169.

interstellar proteinaceous grains.

If true, this would have been a most remarkable finding, so we decided to test it. We therefore measured the absorption spectra, from 320 nm to 200 nm, in solution or suspension, of the amino acid tryptophan; the protein, bovine serum albumin; the nucleic acids, calf thymus DNA and Micrococcus luteus DNA; the viruses, bacteriophages M13 and ΦX174, and nuclear polyhedrosis virus; the Gram positive organism, Bacillus cereus; the Gram negative organism, Escherichia coli; and the cyanobacterium or, as it used to be called, blue-green alga, Merismopedia (these organisms are all prokaryotes); the siliceous diatom, Achnanthes brevipis; and the green alga, Chlorella,which are both eukaryotes. Several of these were measured in thin dry films since interstellar grains would contain no free water.

Whereas there appears to be good agreement between their 280 nm residual peak and that of tryptophan from 310 nm to 250 nm, this is certainly not proof of the presence of tryptophan since many hundreds of known organic molecules have recorded ultraviolet absorption spectra that also fit this peak at 280 nm[14]. In any case, tryptophan is quite labile to ultraviolet radiation and has an absorption band at 220 nm that is 6.3 times higher than the one at 280 nm (Table I). It is therefore excluded, as are proteins in general, virtually all of which contain tryptophan. Still more forcefully, the 280 nm absorption for tryptophan refers to an aqueous solution of the molecule and in general the absorption peak is affected by the solvent and its pH - a phenomenon known in biochemistry as the "universal red shift"[15]. Since one expects no liquid water whatever in the interstellar medium, the appropriate reference must be to the dry amino acid. For dry tryptophan differential scattering can change the position of the observed peak by tens of nanometers and flatten it conspicuously depending on the size and shape of the particles and crystals formed.

Of all the materials we measured (Table II), only tryptophan and bovine serum albumin in solution had peaks near 280 nm. Over the range from 290 to 250 nm all others were dominated by nucleic acids with peaks near 260 nm. In all cases the absorption band from 210 to 200 nm was much higher than the peak between 290 and 250 nm. Thus, the claimed absorption feature cannot be due to the presence of any of these molecules or materials from living or dead, wet or dry organisms, since their claim depended on the almost complete lack of absorption from 240 to 180 nm by the unknown material they believed responsible for the 280 nm peak.

Even if the existence of this claimed 280 nm residual peak of Hoyle and colleagues[4] were not very doubtful because of the degradation of the UV spectra that were used[2,3,16-18], the serious mismatches between the paired program and reference stars, and the uncertainties concerning the effects of the postulated graphite spheres[19] would undermine their conclusions.

Finally, and independently of the validity of the 280 nm residual peak, the absorption features in the infrared, in, for example, the spectrum of the Galactic Center Source, are taken by Hoyle, Wickramasinghe and colleagues to be strong evidence for polysaccharides and bacterial grains[10]. However, the absorbances in the infrared are 100 times smaller than those in the ultraviolet for dried algae and bacteria and the major

TABLE I: COMPARISON OF THE KARIM, HOYLE & WICKRAMASINGHE[4](KHW) 280 nm RESIDUAL PEAK WITH TRYPTOPHAN FROM 310 to 200 nm

	KHW residual peak	Tryptophan
λ(nm)	ΔA*	A†
310	0.00	0.00
300	+0.24	+0.04
290	+0.50	+0.52
280	+0.61	+0.61
270	+0.58	+0.55
260	+0.47	+0.37
250	+0.20	+0.18
240	0.00	+0.12
230	-0.02	+0.91
220	0.00	+3.71
210	+0.01	+2.47
200	+0.02	+2.56
190	+0.02	-
180	+0.02	-

*KHW's[4] excess extinction after subtraction of graphite (0.02μm radius spheres)

†Measured extinction due to tryptophan normalized to A=0.61 at 280 nm

TABLE II: OBSERVED SPECTRAL ABSORPTION RATIOS FOR MATERIALS COMPARED TO THE KARIM, HOYLE & WICKRAMASINGHE[4] RESIDUAL PEAK

Material	λ†(nm)	λ'**(nm)	(λ'/ λ)
Tryptophan	280	220	6.1
Bovine serum albumin (BSA)	279	230	4.0
Trypsin (dry)*	279	200	32
RNAase (in HCl)*	280	200	63
Aldolase (pH 7.4)*	280	200	50
E. coli (envelope protein in $NaHCO_3$)*	275	235	1.4
E. coli	260	220	1.7
E. coli (dry)	260	220	3.1
B. cereus (dry)	260	200	1.4
M 13	258	200	27
Nuclear polyhedrosis virus (NPV)	260	200	15
M. luteus DNA	258	200	1.4
Calf thymus DNA	259	200	1.5
Merismopedia	260	200	1.7
Achnanthes brevipis	260	220	2.9
Chlorella	266	200	1.6
The KHW residual peak	280	240	0.0
The KHW residual peak	280	220	0.0
The KHW residual peak	280	200	0.0

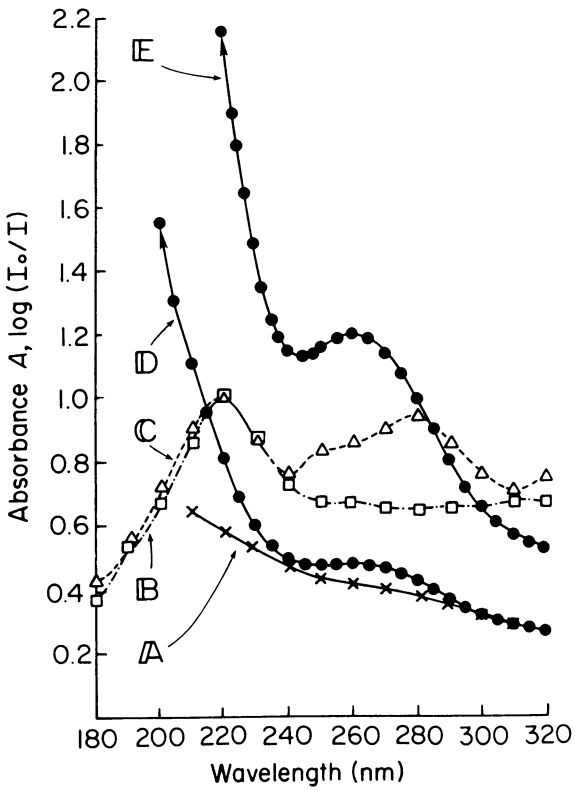
* Data taken from published literature[20]

† Wave length in nm of measured peak absorption

** Where λ' is greater than 200 nm. This means that the absorbance (A) for that sample was greater than 2.000 and could not be recorded accurately at wavelengths down to and including 200 nm.

https://doi.org/10.1017/S0074180900146480 Published online by Cambridge University Press

envelope protein of E. coli[20,21]. Thus if these features were from proteins or polysaccharides in prokaryotes or eukaryotes, the intense far ultraviolet absorption curves due to the interstellar grains would have quite different shapes.



A: an aqueous suspension of coliform bacteria (KHW 1984)

B: IUE low dispersion spectrum of BD-41°7719 in NGC 6231 normalized to A=1.0 at 220 nm (Savage & Sitko 1984). Properly exposed.

C: As B, but 3X overexposed.

D. 0.068 mg. E. coli per ml. Light path 1 cm.

E: 0.218 mg. E. coli per ml. Light path 1 cm.

Fig. 1: Comparison of UV spectra of a reddened star and bacteria

Most recently, Karim, Hoyle & Wickramasinghe[1] published an absorption curve for "coliform bacteria" and compared it with curves from six stars and claim very similar effects near 280 nm. Whereas they stated that saturation did not vitiate their claims and show similar published curves from others, Savage & Sitko's[2] curves for a 3X-overexposed spectrum look just like theirs but had no 280 nm peak for properly exposed data. Fig. 1 shows the redrawn Karim, Hoyle & Wickramasinghe[1] curve for "coliform bacteria" which may show clumping. Fig. 1 also shows our curves at two different concentrations of E. coli. There is no peak at 280 nm, but rather at 260 nm. The absorption increases steeply below 230 nm. The curves are quite inconsistent with those from the reddened stars whether properly exposed or over-exposed. There is no peak at 220 nm for E. coli.

It is remarkable that in their comparison of their bacteria with the reddened star spectrum, Karim, Hoyle & Wickramasinghe[1] cut off the curve from the bacteria just below 230 nm, i.e. before the 220 nm star peak, even though they recorded the spectrum to 210 nm, i.e. past the peak. In any case the absorption rises much more steeply than they show it down to 200 nm and beyond (Fig. 1).

We thus maintain our position - that the evidence now available (see also Duley[22]) excludes an identification of any observed interstellar absorption or scattering feature in the ultraviolet, visible or infrared with tryptophan, proteins, viruses, bacteria, diatoms, or any other living or dried-out, Earth-like biological cells.

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