

OPEN LETTER.

From:-

Dr. Krishna Bahadur,  
M.Sc., D.Phil., D.Sc., D.I.C.(Lond),  
Chemistry Department,  
University of Allahabad,  
Allahabad (India).

To.

Dr. Rutherford Platt,  
Writer of the article,  
"Can Science Create life,"  
appearing in the Reader Digest Vol. 87,  
Indian Edition, September 1965 page 1.

Through.

Dr. Michael Randolph,  
Editor,  
The Reader Digest,  
Head Quarters,  
Pleasantville, N.Y., U.S.A.

Dear Sir,

I am surprised to read the article "Can Science Create Life?" in the September 1965 issue of the Indian Edition of the Reader's Digest. Either the article has been written without obtaining full information of the recent work done by various scientists on this problem through out the world or has been purposely posed to represent a one sided picture of the story with an effort to give undue importance to some approaches, depriving the public of the knowledge of the exact position in this field and undermining the work done by RUSSIAN, English and Indian scientists.

The suppression of the facts begins from the synthesis of amino acids. It was Loeb (1) who in 1913 synthesised amino acids for the first time by passing silent electric discharge in a mixture of formaldehyde, ammonia and water. Using the electrical process in 1953 Miller synthesised amino acids by passing electric discharge in gases which were probably present in the atmosphere of the primitive earth. In 1954 I showed that amino acids can be synthesised photochemically in sterilised aqueous mixtures containing

a source of organic carbon and inorganic catalysts commonly found in soil (2,3). A number of scientific papers have appeared on this aspect by a number of scientists (3,4,5,6,7,8,9,10,11,12,13,14,15,16) and it was in 1958 that Prof. A Neuberger F.R.S. of St. Mary's Hospital, London congratulated me for discovering this simple process of amino acid synthesis in following words:

"It is really an important piece of work and you deserve considerable credit for having been the first in this field, which will probably expand considerably."

I am surprised that you have completely missed to mention this simple process of amino acid formation which in all probability took place in all the pools and oceans of the primitive earth. Instead, you have emphasised electric discharge and many strong radiations as the factors which might have helped in the formation of amino acid completely over looking Hull's (17) thermodynamic considerations of the stability of these resultant products under the influence of the strong radiations enumerated by you.

It is well known that most of the short ultra violet was cut off from reaching the surface of the Earth soon after water appeared on the surface and that water appeared not long after the Earth was formed.

There is still more purposeful suppression of the fact where peptide formation was described in your article. Do you not know our work on photochemical formation of peptides in sterilised aqueous mixtures first published in 1958 (18,19)? Since then the work on this line was carried out in several laboratories

in India and abroad and many scientific papers have appeared on this topic and have been abstracted (20,21,22,23,24,25,26). We have observed that if a sterilised aqueous solution of amino acids and inorganic catalysts is exposed to light a number of peptides are formed in the mixture. The formation of peptides in prebiological era was simple and one need not go near a volcano in search of spots for peptide formation.

On 26th February to 28th February 1963 a symposium on Current Research in Exobiology was held in Jet Propulsion Laboratory, Pasadena with Dr. M.H. Briggs of England as the convenor. In one of the discussions on Prof. J. Oro's paper "the experimental investigation of chemical evolution" in which E. Anders, G. Claus, F. Fitch, N. Horowitz, L. Jaffe, B. Mason, B. Nagy, J. Oro, F. Quimby, O. Reynolds, C. Sagan, myself and many other scientists doing important work on Exobiology were present. Prof. Urey, the Nobel Laureate, said that it is fantastic to seek the formation of peptides near the volcano and a search should be made to discover the process of peptide formation in aqueous mixtures with the help of light and in presence of some of the chelating metals, on which I told him about our work.

Being inspired by this discussion on 17th March 1963 Dr. M.H. Briggs wrote to me from Jet Propulsion Laboratory, California Institute of Technology, Pasadena:

"Your method for synthesizing peptides by light seems to me the most important advance in the field for many years and I should appreciate a full account of your experimental method so that I can attempt to repeat the work".

The details were sent to Dr. M.H. Briggs and on 8th May 1963 he wrote:

"We exposed all the solutions for about three hundred hours to artificial light and all showed some peptide formation."

The work on peptide formation has been confirmed in a number of laboratories and a number of papers have already appeared on this topic. A number of these papers have also been referred in the Bibliography on Exobiology compiled under NASA in the Exobiology Division of the JPL, Pasadena with Dr. M.H. Briggs as the chief editor. I wonder how you managed to miss all that!

Then comes the most astounding aspect of your article. You went to considerable detail discussing Fox's microspheres and their formation under natural conditions near volcanoes. The details of microspheres have been published in several papers by Dr. Fox. There are other molecular associations which have been studied in considerable detail. I wonder what made you to eject out all the work of Prof. Oparin on coacervates and recent observations of Prof. Kalinenko. I wonder what made you to keep mum on our work on "Jeewanu" announced in 1963 which has been published (27,28,29,30,31,32,33,34) abstracted and confirmed twice by Dr. M.H. Briggs (35,36) who repeated many of the experiments himself independently in his own laboratory. Dr. Briggs writes (35):

"Several authors (see review by Oparin (37)) have conducted experiments to duplicate the morphology of cells by interaction of simple inorganic and organic mixtures. While there is no doubt that the products obtained by many of these workers do bear a morphological resemblance to living cells, this is the only feature in

common, in that the products are dissimilar in chemical composition, are metabolically inert, do not grow or reproduce, etc. Moreover most of these artefacts are produced from substances and under conditions that were probably quite absent from the primitive Earth. The only interesting products are those of Fox (38) who has shown that thermally synthesised proteinoids produce microspheres in water.

"However, more recently Bahadur (27) and Perti (31) have described the formation of a series of cell-like microstructures (named by them "Jeevanu", a sanskrit word for "particles of Life") by the action of sunlight or an U.V. lamp on a sterilised solution containing citric acid and a colloidal salt of molybdenum or iron, IT IS THE PURPOSE OF THIS PAPER TO REPORT A CONFIRMATION AND EXTENSION OF THE THIS WORK."

Describing the chemical composition of these molecular associations Dr. Briggs writes (35):

"The primitive hydrosphere was simulated by ashing 1.0 kg. of compressed yeast at 500°C for 12 hours. The resulting ash was examined for cellular remains and for organic matter: neither was detected. The ash was then redissolved in 1.0 litre of triple distilled water.

A variety of organic mixtures was tested, including formaldehyde + ammonium nitrate, acetaldehyde + ammonium nitrate, paraformaldehyde + ammonium phosphate, tyrosine alone, citric acid + ammonium phosphate, a casein-hydrolyste alone. In some experiments the effects of added inorganic suspensions (ferric oxide sol., molybdic oxide sol., alumina) were also investigated.

The solutions were placed in quartz flasks, which were sealed and sterilised by autoclave. Each solution was represented by four flasks in each experiment. Two flasks

of each solution were immediately covered with thick dark cloths and placed in a locked cupboard, while the other two were exposed to the light of a 500 watt bulb continuously for a period of four to six months. In duplicate experiments flasks were exposed to a high pressure mercury UV light with a filter removing radiation below 300  $\mu$ . The flasks were opened and samples of the contents immediately examined microscopically. Some of the samples of the contents of each flask were inoculated into a series of sterile microbial growth-media and agar slopes. These were then sealed and incubated for 2 weeks at 37°C. No growth was detected in any medium or on any slope, indicating the absence of microbial contamination of the flasks.

Microscopic examination of samples from the flasks stored in darkness failed to reveal any microstructures, but samples from all the flasks exposed to light revealed numerous globular structures ranging in size from about 0.5  $\mu$  to 15  $\mu$ . Most of these structures were solitary, but some showed budding, while others were associated in groups ranging from 3 to 15. Similar objects, though in differing quantities, were seen in all flasks.

Larger samples of the light-exposed solutions were now centri-fuged at 5000 r.p.m. for 30 minutes, when the solutions separated into a precipitate and a clear supernatant. Samples of the supernatant and the washed precipitate were subjected to amino acid analysis by high-voltage paper electrophoresis. Samples of solutions kept in the dark were similarly examined. No amino acid was detected in any of the solutions (to which no amino acids had been originally added) stored in darkness. However all flasks exposed to light originally containing aldehydes + ammonium salts now contained free amino acids.

Glycine, glutamate, aspartate and alanine were detected in all. Approximately 0.1% of the added aldehydes were present as free amino acids after 4 months irradiation.

Examination of the precipitates from all flasks revealed the presence of the same four free amino acids. However the precipitates also showed several peptide spots on paper that stained with bromophenol blue, Hydrolysis of the precipitates with 5N HCl, released numerous amino acids that were readily detected on the paper electrophoretograms. From Rf values in several solvents the following amino acids were tentatively identified : glycine, alanine, glutamate, aspartate, histidine, lysine, arginine, serine, threonine, phenylalanine, leucine, valine.

The hydrolysates were also examined by paper chromatography using spraying reagents specific for particular classes of organic compounds. The silver chromate and mercuric nitrate-ammonium sulphide techniques gave positive reactions with areas on the chromatograms with Rf values similar to adenine and guanine. Ammoniacal silver nitrate and aniline-diphenylamine were used for tentatively identifying glucose, fructose, ribose and 2-deoxyribose. Phenolhypochlorite reacted with a compound on all chromatograms with the Rf of urea, while diazotisation reactions showed many spots of which three were tentatively identified as vanillic acid, 3-hydroxybenzoic acid 4-hydroxyphenylacetic acid.

For the irradiation periods used, approximately 1% to 9% of the originally added organic compounds had been converted to other substances.

Tests of the precipitates for enzymatic activity have also been conducted. Esterase, peptidase and phosphatase were searched for in the precipitates using routine micro-clinical assays. Detectable levels of

esterase activity were found in some precipitates, while phosphatase activity was found in others. The levels of activity were very low, but were quite repeatable, though they were undetectable in precipitates heated to 100°C for 5 minutes. No peptidase activity was found in any precipitate.

Detailed microscopic investigation of the more interesting microstructures synthesised by the above techniques revealed the presence of considerable internal architecture. Vacuoles, spherical solid inclusions, and apparent wall-structures were seen in many. Some of the objects fluoresced in the UV, while many were stainable with biological dyes (e.g. acidic carmine, azure II, eosin, haematoxylin-eosin, Janus green B, methylene blue, neutral red ninhydrin, safranin, and toluidine blue)."

Concluding his paper Dr. Briggs writes (36):

"microscopic objects in the 0.5 to 15  $\mu$  size range can be formed by the prolonged action of light on solutions of simple organic compounds in mineral medium simulating the primitive hydrosphere. Some of these objects possess a morphology similar to that of simple cells. The objects contain many of the organic compounds found in protoplasm. Some also appear to possess weak enzymatic activity.

While the definitions of "life" and "living" are difficult problems, it can be said that these microscopic objects satisfy many of the criteria of living cells. It seems entirely probable that objects similar to those observed in the present experiments were formed in abundance in oceans of the primitive Earth and were the immediate precursors of cellular life."

Thus Dr. Briggs confirmed our observations on

1. Photochemical formation of amino acids.
2. Photochemical formation of peptides
3. Abiogenic formation of enzymically active materials (39)
4. Formation of Jeewanu, the protocells under conditions which were in existence in all the oceans of the primitive Earth and that light played an important role in this process (28,32).

And the most remarkable is your statment about Fox's microspheres when you write "the significance of these microspheres is that scientists did not synthesise them piece by piece, they simply set up the right conditions and microspheres produced themselves." and the last sentance of your article which runs as: "IT BECOMES HARD TO AVOID THE PREMISE THAT LIFE IS INHERENT IN MATTER, and that life will exist on other planets whenever the conditions are right" is written in a manner as if it is your own conclusion. Please note that in our paper entitled "Synthesis of Jeewanu, the units capable of growth, multiplication and metabolic activity" part I, published in Zentralblatt fur Bakteriologie, 117, 567-574 (1964) it has been said that in our opinion matter has inherent properties of duplication and adaptability i.e. in short and popular language LIFE IS INHERENT IN MATTER and it is only manifested under certain conditions resulting in objects with properties of biological order i.e. the properties of growth, multiplication and metabolic activity. On page 572 of the above mentioned paper the last paragraph begins as follows:-

"Thus amongst the processes of opposite natures as solubility and insolubility, the sol and gel phases of materials, permeability and impermeability, hydration and dehydration, absorption and exclusion, reactivity

and inactivity of the materials of the globules amongst themselves and with the materials in the environment and through many such processes depending on the physico-chemical conditions of the substances concerned, was present a course through which the inherent properties of matter, duplication and adaptability could operate and this resulted in units where the effects which we know as those of the livings - growth, multiplication and metabolic activity - could be observed."

Further on page 573 of the same paper it has been written:

"Thus in short the matter of producing units capable of growth, division and metabolic activity is a question of putting the matter in such a way that it can manifest its properties and is like a surgical operation where the things are set right by necessary alteration and adjustment and the body does the rest."

Again in my paper entitled, "Conversion of lifeless matter into living system" published in Zentralblatt für Bakteriologie, 118, 672 - 694 (1964) on page 685 paragraph two it has been written:

"Thus considering the duplication and adaptability as the inherent properties of matter it is possible to produce such systems of matter which when placed under suitable conditions and in a proper environment, show the properties of duplication and adaptability. Such systems have been prepared from a number of materials and a detailed account of their morphological appearance has been given and the procedures for their formation have been described (29,30,31,33)"

"Lwoff's work shows that evolution is not the gain in the properties of the individual cell but is the loss of the properties (40). It is improbable that a cell formed empirically could have been so full of properties

which only decreased with the progress of evolution and it is easy to think of a system getting formed because of the physico-chemical properties of the matter concerned and of the environment in which it is formed and then operating and showing the properties of growth, multiplication and metabolic activity because of the inherent properties of duplication and adaptability of the matter which are manifested in that environment of the system."

On page no. 682 of the same paper 31st line begins as follows:

"It has been suggested by us that the molecules constituting a living system formed it under suitable conditions not per chance but because of some inherent properties of matter. We believe that matter has two additional properties other than what are already known and these are of adaptability and duplication."

You may be familiar with the Wakula conference held at Tallahassee in November 1963. The conference was organised by the Exobiology Division of NASA with Dr. Fox as the convenor. Different aspects of the problem of Origin of Life were discussed in the conference. Prof. J.B.S. Haldane had gone to attend the conference from India. After his return from the conference Prof. Haldane wrote to me in letter No.64/0019 dated 9th April 1964:

"I was at Tallahassee early in November. I was sorry that you were not there, as your Jcewanu are in some way more lifelike than his microspheres."

In view of the above facts will you please write as how for you were just in writing that article the way you wrote, for it not only gave a wrong impression

to the readers but also did injustice to the other workers whose work should have been give proper place in your article. May I request you to either amend the article in the form of a new article or write a note or letter to the Editor of the Reader's Digest which should appear in the same magazine.

I am further interested in your personal contribution in the field of origin of life. On going through the above referred bibliography I could find only one paper of yours referred entitled, " On the nature and colour of the moon's surface," Science, 127, 1502-3 (1958).

If you have done any other work on abiogenesis of the materials of interest in Biopoesis or any other work in this field. I will be extremely thankful if you send me the reprints of those papers or at least their references for that will enable me to understand your process of thinking and I may be able to explain my work to you on more scientific basis,

Expecting an early reply from you,

With my best regards.

Yours sincerely,

*Krishna Bahadur*

(Krishna Bahadur)

30th September 1965.

Copies sent to 200 top scientists of the world working in the field of origin of life on the Earth.