Meeting Reports

UCL Symposium on the Origin of Life

11 November 2011

Mark Burgess (Executive Editor)

After an introduction by Finn Werner, Professor G. David Price gave a brief overview of the University College London (UCL) Origin of Life Initiative, of which this free symposium was a part. UCL has developed what it calls an 'Origin of Life Reactor'.

This symposium brought together scientists from a number of disciplines including planetary sciences, chemistry, molecular and microbiology, biophysics and evolution.

The first lecture was given by Professor Karl Stetter, who has managed to discover over 50 new species, 18 new genera, nine new orders and an entire kingdom, Nanoarchaeotes. He gave a clear and entertaining history of his researches on hyperthermophiles and their application to the history of life on Earth. Hyperthermophiles grow best at above 80°C (some do not grow at all below that) and belong to either of the prokaryotic domains, the Bacteria or the Archaea. *Thermoproteus* has been cultured at 97°C, *Pyrodictum occultum* at 105°C and *Pyrolobus fumarii* at 113°C. The last can withstand autoclaving at 212°C for an hour. In 2002, Professor Stetter discovered *Nanoarchaeum equitans* in a hydrothermal vent off the coast of Iceland; this has the smallest known genome and is about the size of a large virus (~0.4 μm). It lives symbiotically on the thermophile *Ignicoccus hospitalis*. Living at such elevated temperatures calls for special biochemistry, and it is noticeable that hyperthermophiles use ether lipids rather than ester lipids.

The next section, 'Planetary Science and Biology', was introduced by Lewis Darnell. Euan Nisbet gave a quick sketch of the history of life on Earth. His research in the Belingwe Greenstone Belt, Zimbabwe, (2.8 billion years old) have produced early life signatures and evidence for a diverse prokaryotic mat ecology.

Graham Shields-Zhou gave an account of plate tectonics and posed the question 'did it exist in the Achaean, and does it depend on water?' before considering the appearance of the early Earth and the Hadean 'waterworld'. He suggested the progression "luck=water=tectonics & O_2=life=complexity=climate stabilization [he shied away from the 'G' (Gaia) word].

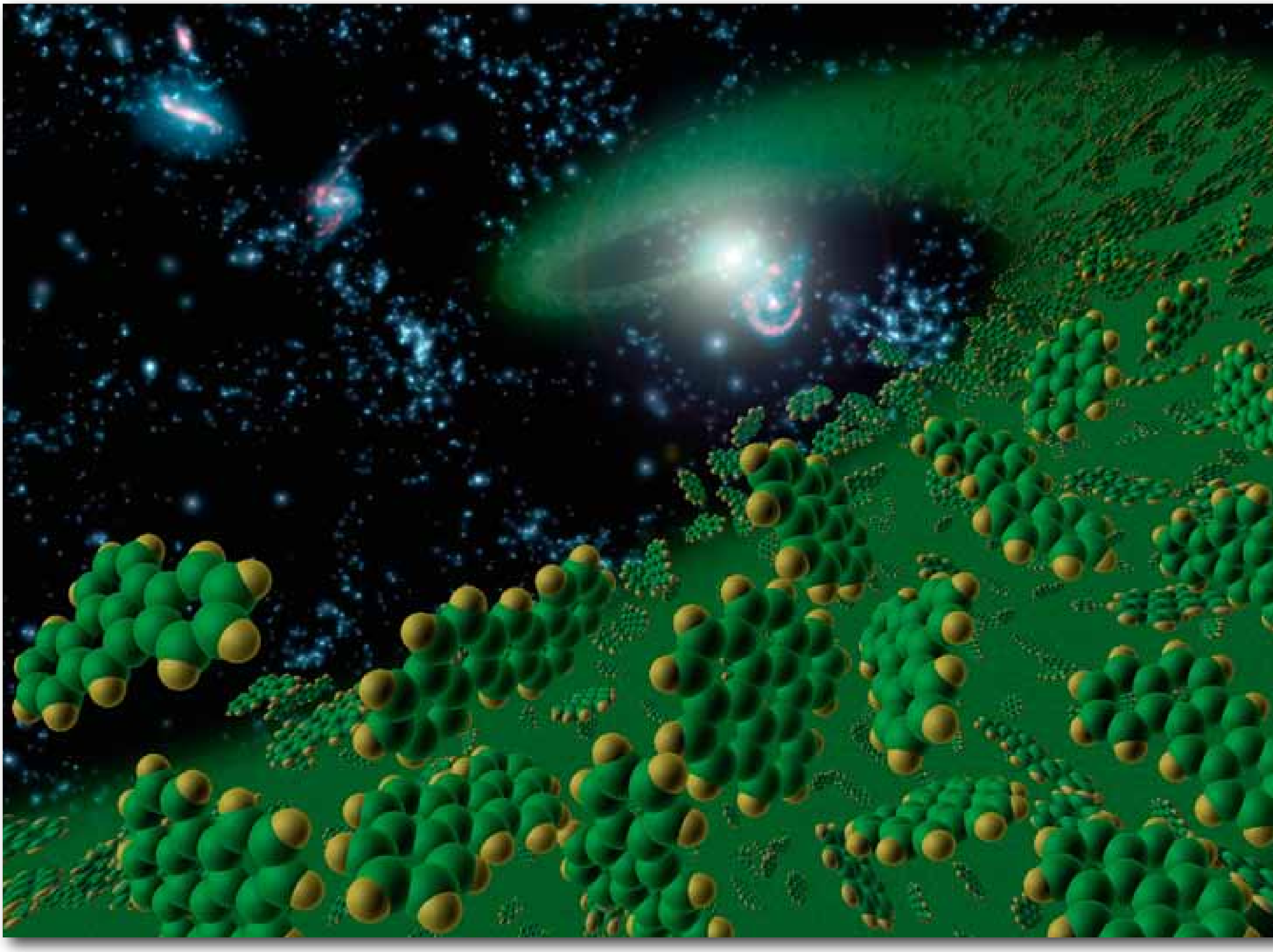
Nick Lane introduced the next topic, 'Chemistry and Computation', which began with Professor Ernesto DiMauro sketching out a plausible path from one-carbon molecules to RNA. He pointed out that the simplest molecules grouping the four most common elements of the universe (hydrogen, carbon, oxygen and nitrogen) are isocyanate (HNCO) and formamide (H_2NCOH). There are reasons for supposing the existence of formamide on the prebiotic Earth and, with simple and common catalysts (such as the clay montmorillonite), will yield the complete set of nucleic bases necessary for the formation of nucleic acids. Life, he suggested, was the hypercycle of the HCN and H_2O cycles. In sum, Darwin's 'warm little pond' was still possible, although more likely to be a hydrothermal vent.

Professor Peter Coveney spoke on 'Origins of Life: Theory, Modelling and Simulation'. Theoretical modelling covered hypercycles, the RNA world, compartmentalization (e.g. micelles, liposome bilayer sheets), molecular modelling (e.g. Monte Carlo simulations) and the origins of homochirality (the origins of handedness and polymerization).

He was sceptical of the 'primordial soup', stating that there was no geochemical evidence, that concentration would always be a problem, that the soup would be exposed to the destructive effects of UV light as well a source of energy and that a primordial soup cannot be in thermodynamic equilibrium. He thought the likeliest sources of life were the alkaline hydrothermal vents.

Professor William Martin, came on after lunch with a spirited talk: 'Bringing Rocks to Life: the Early Evolution of Biological Energy Conservation'. He described the plant cell as "the tree of life all wrapped into one"; the mitochondrion, an endosymbiotic protobacterium, and the chloroplast, an endosymbiotic cyanobacterium, still have their own genomes. He too argued that the primordial soup idea was a non-starter and that alkaline hydrothermal vents provided a concentration mechanism, the right chemicals and a temperature of about 70°C (instead of the 350°C of the 'black smokers'). Hydrogen from water reduced by Fe^{2+} and transported to the vent/ocean interface could be used to fix CO_2. With the vents at pH 9–11 and the ocean at pH 6, one has a natural proton gradient. Life it seems, is all redox chemistry or, as Albert Szent-Gyorgi said, "Life is nothing but an electron looking for a place to rest."

Nick Lane spoke on the origins of coupling; how did proton gradients become coupled to carbon fixation



and how did proton gradients become coupled to ATP synthesis? The answer lies in chemiosmosis, described by Leslie Orgel as the most counterintuitive idea in biology since Darwin, which gives a route by which energy production is disconnected from ATP synthesis.

Discussing the Last Universal Common Ancestor (LUCA), Dr Lane noted that bacteria and archaea lack homologous cell walls and cell membranes (i.e. they have evolved the barriers between inside and outside independently) and so might not have been free-living cells, but rather confined to the micropores of alkaline hydrothermal vents. However, some subunits of the ATP synthase are homologous in bacteria and archaea, so arguably the LUCA could draw on the natural proton gradients in alkaline vents.

Wolfgang Nitschke talked about 'The Deep Phylogenetic Roots of Metabolic Enzymes'. He pointed out that "bioenergetic enzymes are built according to the Lego principle"; and asked how one can distinguish between pre- and post-LUCA enzymes. It is pointless to look to see whether an enzyme is shared between the Bacteria and the Archaea – gene transfer makes a nonsense of this. One must look for a significant coincidence between species (indeed, enzyme phylogenies can be used as markers for the oxidation state of the environment) and for roots lying in between the Bacteria and the Archaea. The oldest enzymes are metalloenzymes, with metal centres which have inorganic or mineral analogues; metals, he argued, were the first catalysts and LUCA used them, especially molybdenum, widely. It was interesting to note that no pre-LUCA enzyme converts heterotrophic substrates.

Professor John Ward, in 'Linking Ancient Enzymes and Prebiotic Cycles with Synthetic Biology', noted that there were over 131 simple molecules found in interstellar dust and complex molecules in circumstellar dust and carbonaceous meteorites; sugars and nucleic acid bases could be formed early on in the universe; enzymes came later. Much of the lecture dwelt on the transketolase, which operates in the pentose phosphate pathway in animals and the Calvin cycle in plants, catalysing two important reactions that operate in opposite directions in the two pathways.

Professor Ward chaired the next session: ‘The RNA world – information processing in living systems’. The speaker was Dieter Braun on ‘Thermal Solutions for Molecular Evolution’ who considered the Eigen paradox: how can RNA code for proteins when RNA needs proteins? The answer was tRNA as a replicator (a sort of tRNA world).

Finn Werner was next, with ‘Nucleic Acid Polymerisation - Molecular Mechanisms of Information Processing’. RNA is an extremely versatile biomolecule in as much that it can have a genotype (it encodes genetic information) and a phenotype (it carries out function). In addition, small non-coding RNAs have recently emerged as important regulators of replication, transcription and translation. In essence, RNA is the centrepiece of life, and its synthesis by RNA polymerases (RNAPs) deserves our special attention. He pointed out that all cellular RNA polymerases (responsible for transcribing the genomes of all living organisms), without any exceptions, are evolutionarily related, which suggests that they are derived from one common ancestor. This common descent is reflected in their sequence, structure and function – as in the basal factors that regulate RNAP activity. Werner speculated on the early evolution of RNAPs (pre-LUCA) and set out a novel theory: a paradigm shift according to which ancient RNAPs were regulated during the elongation phase of transcription, and not during initiation.

Nick Lane brought proceedings to a close with a concise and clear summary of the day’s proceedings, summarizing the difference between early life and life today as follows:

Driving force	CO_2/H_2 disequilibrium	carbon capture
Metabolism	catalysis by minerals	catalysis
Integrity	inorganic compartments	cell walls
Heredity	replication via thermal trapping	replication
Energy	natural redox and proton gradients	energy transduction
Excretion	venting of waste	excretion

The alkaline vents are good candidates for the origin of life and the UCL is working to produce an artificial vent with an AlO_2 matrix.

It was a satisfying end to a fascinating day. ■

RNA-UK 2012

An Independent Meeting supported by the Biochemical Society; 20–22 January 2012, Burnside Hotel, Bowness-on-Windermere, Cumbria, UK

Ray O’Keefe and Mark Ashe (University of Manchester, UK)

This biennial meeting brings the RNA community in the UK together for a long weekend to discuss the current research in the field within the beautiful setting of the Lake District. Demand to attend this meeting was very high and, unfortunately, the organizers had to turn people down due to the limitations of the venue. This, however, indicates that the RNA field in the UK is growing, underlining the importance of RNA in many biological processes.

The majority of talks at the meeting were presented by PhD students and postdocs, allowing the opportunity for these younger researchers to present their work. The range of topics presented on RNA was extensive and was highlighted by a programme that did not consist of any specifically themed sessions. Topics included coupling of transcription to RNA-processing events, pre-mRNA splicing, polyadenylation, translation, RNA localization, RNA editing, RNA decay, microRNA biogenesis, microRNAs in disease, non-coding RNAs, RNA pathway modelling, RNA structure and tools for investigating RNA. Those who were not chosen to give a talk were given the opportunity to present their work as a poster. An evening poster session was a new addition to RNA-UK and it proved to be very successful. Participants were able to view the posters and have further discussions on RNA in the bar conveniently located next to the posters.

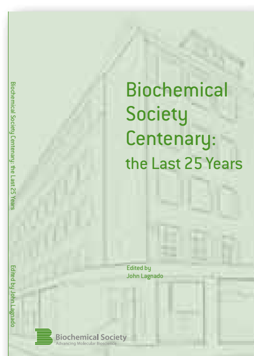
A tradition for RNA-UK is having the Saturday afternoon free to enjoy walking or other activities in the Lake District. As in previous years, Mother Nature was kind and provided a relatively dry but

windy afternoon for the organized walks. At the end of a busy weekend of RNA, with some very high quality talks and posters, two prizes, sponsored by Stratech Scientific, were awarded for the best talk and poster. Guillaume Hautbergue (University of Sheffield) won the talk prize for 'The molecular basis for the action of the Vietnam time bomb' and Alex Tuck (University of Edinburgh) won the poster prize for 'Judging *Saccharomyces cerevisiae* non-coding RNAs by what they wear'. Overall, the meeting was a great success displaying the wide diversity of biological processes that are now known to involve RNA. We thank the Biochemical Society for their generous support of the meeting. ■

Papers from this meeting will be published in *Biochemical Society Transactions* issue 40(4).

Letter to the Editor

The History of the Biochemical Society



Having read the previous three histories of the Society, I read the latest account (2011) with interest. Busy scientists all struggle to keep up with reading the publications in their particular field. So they may be disinclined to put this publication on their reading list. But they should all read this interesting, informative and important document.

The Society has been much more active in the education area: postgraduate, undergraduate and even at the level of schoolchildren. Also the enormous surge of studies in molecular biology must astonish us all.

When I served as a junior member of the Society Committee (1966–1970), I was surprised to see how very busy senior members gave up their valuable time so freely to guide the activities of the Society. This latest history reviews the progress over the last 25 years. All members can be sure that all of these activities are in safe hands for the next hundred years.

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Histories of the Biochemical Society are available at:
www.biochemistry.org/history.aspx