BOOK REVIEWS

John M. Robson (ed.), *Origin and Evolution of the Universe: Evidence for Design?*, McGill-Queen's University Press, Montreal, 1987, xiii+297 pp., $(Can) 35.00 (hb); $(Can) 15.95 (pb).

This is a collection of essays, based on a symposium sponsored (in 1985) by the Royal Society of Canada on the origin of the universe with special respect to the question of design – or, rather, to the question of Design. As is usually the case with these sorts of productions, the quality is uneven, with the best being interesting and even exciting, and the worst looking like a quick payment for one's airfare to the conference.

The authors, many Canadian but with a good smattering of visitors, include biologists (primarily of the molecular variety), physicists, philosophers, theologians and others. Generally, they have made the effort, successfully, to be comprehensible both to their fellow professionals drawn from other fields and to people who are not on the edge of research, either in science or the humanities. For this reason, one can pick up without a certain effort a fairly broad range of informative items from a number of topics, be these elementary genetics (Robert Haynes, Barry Glickman, Ford Doolittle), elementary probability theory (Ian Hacking), cosmology (James Lovelock), geology (Digby McLaren), and more.

Generally, the contributors stay on topic, and explain why (or why not) their subject tells us someting about God's hand in the universe. Although, there are one or two of that ilk which appear in any interdisciplinary symposium, no matter what the theme: you talk about your own work and then end with the stock paragraph about "the time is short and it may be too late, but unless we take action our survival is threatened by –" (the blank to be filled in by "acid rain", "the bomb", "the population explosion" or "the destruction of the rain forests"). If you think I am unduly cynical, just take a look at p. 208 of this volume.

For my money, although you must recognize that I am a philosopher talking about a fellow philosopher, the best paper in the collection is by Hacking, who shows quickly and clearly how fallacious thinking about probability can quickly tip us into thinking that there is Purpose when there reallly is none. In the currently popular jargon of "anthropic principles", Hacking neatly shows how a weak version of such a principle – that we see the universe through the spectacles of our own sensations and thought processes – probably tips many into accepting a strong version of such a principle – that the world is as it is despite great improbability, and hence there must be Some Reason.

In a way, however, I think this collection is better looked on as a phenomenon for

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study in itself than as a guide to information. If you want to dig into modern thinking about Design and the universe, you had do better to look at Frank Barrow and John Tipler's *The Anthropic Principle* (Oxford, 1985) rambling and opinionated though it may be. Here, the interest is why, over, a hundred years after Charles Darwin's *Origin of Species* drove a stake through the heart of William Paley's *Natural Theology*, scientists (especially those at the physical end of the spectrum) still hanker after the Great Molecule in the sky. Typical is Doolittle, an eminent molecular biologist, who spends virtually all of his space telling us how to get functioning life without initiating Purpose, but then collapses into mystical yearnings on the last page.

There may not be a Designer, but if this volume tells us anything, it is that humans have a desperate urge to believe in one.

University of Guelph MICHAEL RUSE
Ontario, Canada

William F. Loomis, *Four Billion Years: An Essay on the Evolution of Genes and Organisms*, Sinauer Associates, Inc., Publishers, Sunderland, Mass., 1988.

Scientific disciplines, like living organisms, evolve. In their initial stages, confusion reigns: a few facts are known, there are some long-standing practical applications, but little or no intellectual structure exists to guide those who would explore the field, and the relative importance of this or that detail cannot be objectively assessed. Following this chaotic infancy typically comes a period of rapid growth of factual information – fueled by technical inventions which allow the accumulation of vast quantities of new data. Then at some point or points an adolescent transformation or metamorphosis takes place as a structure of ideas emerges to provide an organizing framework for the science. Mere description becomes subordinated to logical explanation – information ceases to be an end in itself, but instead supports deeper understanding.

Biochemistry – by which term I will designate all of the 'molecular life sciences' – has molted several times in the last 30 years and can be seen now as quite a strapping adolescent, probably on the threshold of its true maturity. From a collection of disparate, sometimes contradictory, and often confusing facts, it has become an organized structure of knowledge which has moved a long way towards its ultimate destiny of providing sound chemical explanations for biological phenomena. We can easily identify some of the stages of this development: (1) the rise to prominence of structural chemistry as pioneered, for example, by Linus Pauling, Max Perutz and John Kendrew; (2) the emergence of the 'central dogma' of molecular biology with its insight into the role of nucleic acids in life processes – heavily contributed to by James Watson, Francis Crick, Jacques Monod and Francois Jacob; (3) the appreciation of the basic principles of bioenergetics by Fritz Lipmann, Albert Lehninger and others. Each of these advances has allowed an integration of our knowledge and begun to open the door for a kind of 'teleological biochemistry' which not only helps to explain why cells operate as they do on the molecular level, but also begins to have predictive power – the hallmark of any genuinely advanced discipline.

In *Four Billion Years* Loomis addresses another central organizing principle which promises to have an increasingly major influence on the way in which biochemists think about their subject, namely, basic understanding of the process(es) whereby inanimate matter became living and then developed the fascinatingly complex molecular organization so avidly elucidated today. This isn't a new subject, and indeed most textbooks of biochemistry have made at least passing reference to it for quite some time. What is new, however, is the amount of detailed, reliable information made available in the last 5–10 years which bears directly on the topic. Discussions of the origin of life and biochemical evolution as recently as the mid-1970s were fraught with the risk that Mark Twain's famous aphorism ('Science is fascinating, one gets such wholesale returns of conjecture for such a trifling investment of fact!') would fit them all too well. In the late 1980s, however, it seems fair to say that we have reached a watershed, chiefly as the result of advances in recombinant DNA technology and DNA sequencing – though other sources of information have also contributed significantly. We are beginning to have enough facts that what once had to be unsubstantiated speculation can now have the force of reasoned argument.

Loomis has attempted a preliminary version of what amounts to a grand synthesis of our present knowledge of how biochemical (and genetic) systems have come into being and developed over time. He rightly terms it an essay, implying both the personal perspective and tentative quality connoted by that term. The approach is not altogether novel – much of the same ground was covered by Margulis in *Symbiosis in Cell Evolution* (Freeman, 1981) – and the details are fairly skimpy. [Those who would like something meatier should turn to the most recent volume (LII, 1987) of *Cold Spring Harbor Symposia on Quantitative Biology* which somewhat transcends its title: 'Evolution of Catalytic Function.'] Nevertheless, I found *Four Billion Years* a useful summary. Each chapter has extensive notes and an impressive, up-to-date bibliography which should prove helpful to anyone seeking an entry into the literature on one of the many topics which fall within the scope of this broad-brush treatment.

Readers will doubtless find points with which they will disagree, or emphases that seem misplaced. The speculation that on another planet some organisms might use RNA as the genetic material and DNA as its messenger (p. 58) flies in the face of the chemical qualifications which admirably suit these macromolecules for the roles they play in terrestrial organisms. Similarly, the choice of ATP (rather than GTP or CTP) as the universal energy carrier hardly seems 'happenstance' (p. 57), given the quantitative predominance of adenine in simulations of prebiotic chemical evolution. Failure to describe attenuation as a regulatory mechanism for gene expression in the histidine operon (p. 159) unfortunately leaves out one of the more fascinating ways cells have exploited the physicochemical capacities of their component molecules. Likewise, not mentioning the well-documented gene-regulatory system of *E. coli* bacteriophage lambda seriously weakens the discussion of regulatory circuits (p. 245). Exchange of DNA between prokaryotes cannot proceed with 'no regard for whether the DNA comes from the same or a different species' (p. 150) – the whole point of restriction nuclease/methylase systems is to limit just such exchanges!

The book also has some minor errors which can be irritating, from repeated misspellings of solenoid to the use of 'configuration' where 'conformation' is the correct term. Loomis also fails to distinguish between amination and amidation, a point which will probably only bother chemists. Stylistically the writing ranges from the pedestrian to the eloquent and quotable. I found the repetition of some themes (*e.g.*, random generation of slightly more effective catalytic peptides must have led to improved efficiency of the systems of which they were components) tiresome and unnecessary.

Two substantive issues get short shrift in the book. One is the detailed evidence for oxygen levels in the evolving atmosphere. Apart from the very qualitative figure given in the introduction (p. 3), nothing approaching hard data on this point appears, even though the transition from a reducing to an oxidizing atmosphere and the subsequent increase in P_{O_2} has played one of the most dominant roles in the process of biochemical evolution, as Loomis makes clear at numerous junctures. Perhaps next to nothing really is known about this crucial topic. If so, that point deserves much greater emphasis – even to the point of exhorting the relevant disciplines to address the lacuna. The other issue concerns the matter of gene transfer between phylogenetically distant organisms. Just because two organisms share significant elements of DNA (or protein) sequence, we cannot *unequivocally* interpret those homologies as coming from uninterrupted descent since divergence from a common ancestral line. That is, of course, the simplest interpretation, and in most instances probably correct. Utter, unquestioning reliance on it, however, seems unwarranted in light of the enormous complexity of the biological world. After all, only a decade ago no one even imagined that introns existed! Loomis refers to this point tangentially a couple of times, but a paragraph or two of serious discussion of it would have improved the book.

All criticism aside, this is a useful book which every biochemist (molecular biologist, geneticist...) should read. Certainly our teaching, and perhaps also our research would be enhanced by the kind of comprehensive evolutionary perspective which Loomis employs. At the very least, the extent to which recent findings drive home Jacob's point that 'evolution, like the tinker, does not produce innovations from scratch' ought to affect the way we think about our subject. Clearly the story of how biochemical systems 'got that way' has more than just historical significance – it provides another approach to organize the welter of factual detail which nicely complements structural chemistry, the central dogma, and bioenergetics.

Boston University, Department of Chemistry,
Boston, Massachusetts 02215, U.S.A.

SCOTT C. MOHR

The Emergence of Life: Darwinian Evolution from the Inside, Basic Books Inc., New York, 1988, 208 pp., $17.95.

In his book *The Emergence of Life: Darwinian Evolution from the Inside*, Sidney Fox gives an easy to read summary of his approach to the origin of life question. The historical background and the significant driving ideas are well documented. An important part of the book includes several incursions into philosophy, the presentation of a new evolutionary paradigm and a skillful criticism of creationism. This 'on men and ideas' contribution is very interesting, well written and denotes an in depth reflection on the subject.

The scientific contribution of the author is largely described and can be summarized as follows: when heated, a mixture of amino acids condenses to give a polymeric material (proteinoids) which is able to organize itself into cell-like structures. During the thermal condensation, amino acids order themselves to provide privileged amino acid sequences. Proteinoids exhibit catalytic activity (hydrolysis, decarboxylation, amination and deamination). In particular, 'lysine-rich proteinoids catalyze the synthesis of peptide bonds and of phosphodiester bonds' (p. 102). Thus, 'a kind of protein can be made in the geological environment without cells' (p. 66) and 'these molecules had many of the functions of modern proteins' (p. 66).

These statements may mislead the readers who would not carefully read the literature cited by the author. What does this literature say? The polymeric character of proteinoids and their ability to organize themselves into microparticles are well established. With regard to catalytic activity, it must however be noted that the synthesis of phosphodiester bonds is limited to small amounts of trinucleotides. On the other hand, only small amounts of the tripeptide were obtained from phenylalanine and the reaction required the presence of ATP and preformed poly A (S. W. Fox, J. R. Jungck, and T. Nakashima, *Origins of Life* **5**, 1974, pp. 227–237). In general, proteinoids are not entirely composed of condensed amino acids (K. Dose, *Origins of Life* **5**, 1974, pp. 239–252), side reactions during thermal condensation leading to largely unknown products linked to the peptidic fraction. Under these conditions, it is rather hazardous to associate the activity of the proteinoids to their peptidic fraction considered as part of the continuum between amino-acids and proteins.

Self-ordering of amino acids in privileged sequences during proteinoid formation is also questionable. Non-randomness is established insofar as proteinoids have limited heterogeneities in chain length and in amino-acid composition. In addition, all the chains begin with pyroglutamic acid when glutamic acid is present in the reaction mixture. Non-randomness will become self-ordering if a significant amount of chains presenting a similar sequence is formed during the condensation step. This is not what happens, contrary to what is claimed by the author. Martinez Luque-Romero *et al.* (*BioSystems* **19**, 1986, pp. 267–272) analyzed the non-dialysable fraction of an Asp-containing thermal polymer having a mean molecular weight of 7700. Polyacrylamide gel electrophoresis and isoelectric focusing gave a unique band but anion exchange chromatography indicated a rather high degree of heterogeneity. Melius and Hubbard (*BioSystems* **20**, 1987, pp. 213–217) studied the thermal polymer obtained from a mixture of eight amino acids including Glu and Asp. The non-dialysable fraction contained all the amino acids at the N-terminus. For the diffusible fraction, N-termini are pyroglutamic acid but all the types of amino acids appeared as penultimate to the N-terminus position. Thermal treatment of a mixture of Glu, Tyr and Gly afforded oligopeptides, polymers and chromophores. Among the short peptides, only cyclic (glycyl-tyrosine), pyro-glutamyl-tyrosyl-glycine and pyroglutamyl-glycyl-tyrosine were found (J. Hartmann, M. Ch. Brand and K. Dose, *BioSystems* **13**, 1981, pp. 141–147) confirming earlier results by Nakashima *et al.* (*Int. J. Quant. Chem.: Quant. Biol. Symp.* **4**, 1977, pp. 65–72). It must be noted that the ordering concerns very short sequences and only a fraction of the thermal polycondensate.

Chemical evolution had to polymerize amino acids but had also to develop chemical selection in order to afford proteins with restricted complexity. Proteinoids are not completely random but there is a long way from complete randomness to real ordering affording selected sequences. What is the ordering threshold from which chemical evolution took advantage? S. Fox only just mentions that when heating a mixture of selected L-amino acids, one gets a polycondensate which is about 50% peptidic, the peptidic fraction is racemized (Hartmann *et al.*, 1981, *loc. cit.*), the peptide linkages are ambiguous since they include α, β and γ functions (Temussi *et al.*, *J. Mol. Evol.* **7**, 1976, pp. 105–110) and the sequences are multiple although not completely random. The main gain is the polymeric character and the organization into particles but the price for it is high because of the dramatic increase in complexity. Chemical selection had therefore to process the proteinoids in order to extract and transform the peptidic fraction into well-defined homochiral, α-linked poly amino acids. This might have been a serious challenge.

Sidney Fox occupies a front seat in the scientific community of chemical evolution. The readers involved in the field will follow with interest the proteinoid story. They will be sensitive to the strong conviction of the author, to his anecdotes, pointed remarks and to his humour. It will certainly be difficult for some readers to escort the author in all of his assertions, especially when he associates the thermal proteinoids to mind and aging.

CNRS, Centre de Biophysique Moléculaire
Orléans, France

ANDRÉ BRACK