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Phosphorus Chemistry. The Role of Phosphorus in Prebiotic Chemistry. By Yufen Zhao, Yan Liu, Xiang Gao and Pengxiang Xu. DeGruyter, 2018. Pp. XVI+166. EUR 119.95 USD 137.99 GBP 109.00, hardcover, ISBN 978-3-11-056237-8.

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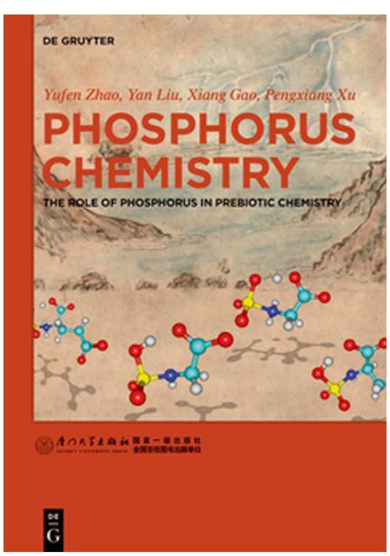

Phosphorus Chemistry has been published jointly by de Gruyter in Europe and Xiamen University press in China, but it is the subtitle *The role of phosphorus in prebiotic chemistry* that gives a good indication of the content and context of the book. Written by Professor Yufen Zhao and her colleagues, this book of 166 pages is very thin as far as the number of pages is concerned but its chemical, biological and finally philosophical implications are remarkable. Being highly interested in the relationship between chemistry and biology, philosophy and the creation of life (*e.g.* see the following article in *The Conversation*, https://theconversation.com/conversation-between-a-biologist-and-a-philosopher-has-man-become-a-semi-god-3-88911), I have been totally fascinated by the story that unfolds therein. In the book, the authors constantly and rightly refer to the famous Miller–Urey (or more simply Miller) lightning experiment, which was published 66 years ago and where they created the basic molecules of life (bases of the nucleotides, amino acids) from chemicals (mainly ammonia, methane, hydrogen and water). This has led to prebiotic chemistry, and the work of the Zhao laboratory in Xiamen is part of that international effort. More specifically Zhao and her colleagues have contributed to revealing the importance of including phosphorus in the prebiotic soup. For example the Miller experiment leads to the production of ten amino acids but if PH_3 is added as a catalyst, then 19 different amino acids are detected. 'Simple' chemical reactions explain how the NH_2 of the amino acids can react with phosphorus to become phosphorylated (they then become N-phosphorylated amino acids, designated as NPAAs) and how this modification via the formation of a transitory cyclic CAPA2 molecule in turn favors the creation of dipeptides, tripeptides *etc.*, leading to the possibility of creating small and increasingly complex proteins. They also propose convincing scenarios where NPAAs can serve as catalysts for the formation of nucleosides from the nitrogen-containing bases A, C, G and T, and also of lipids, the constituents of membranes. A very interesting section is devoted to the early genetic code where the information that may have first been encoded by a single base evolves into a system where two bases were needed and finally three in the current genetic code. Chemistry also suggests that in the original conditions where life appeared, minerals such as hydroxyapatite (a polymer of phosphate) have probably been used for heterogeneous catalysis. It seems that the group of Professor Zhao has been heavily involved in prebiotic chemistry (see for example a list of their publications at https://scholar.google.ca/citations?user=upCz5CEAAAAJ&hl=en) contributing in particular to the identification of the dipeptide Ser-His as being one of the early biocatalysts (it can cleave DNA and proteins), but also to various chemical aspects of prebiotic chemistry. In particular, they have published a number of papers where they studied the inclusion of iron or copper in synthetic reactions. This is actually one limitation of the current book, of course phosphate is essential, massive amounts are needed for biological systems to operate, but on the other hand as plant nutrition tells us, many other metals like copper, iron, manganese, selenium, nickel, zinc *etc.* are needed in small quantities . It would have been nice to discuss this to some extent, especially as this group has obviously experience and interest concerning the inclusion of metals in chemistry.

Of course the book has strengths and weaknesses; on the weak side the command of English is not always perfect (for example they relate to the Miller–Urey experiment as

Miler–Yuri) but it remains understandable although there are numerous bugs present. Something that is also missing is an index, which would have been very useful for the reader, and a list of abbreviations. The figures are of good quality but the legends are very often on the minimal side. These imperfections aside, I strongly recommend reading this book if you are interested in prebiotic chemistry. It is a short read but it will, in ten successive chapters, explain to you how life has originated on Earth either in small ponds or in the dark chimneys in the ocean ridges with high temperature and high pressure. Obviously the chemical nature of phosphate has been essential to drive the creation of amino acids and proteins, nucleotides and nucleic acids, lipids and membranes, in short, the major constituents of life. To me, life is a natural consequence of matter and thought is a natural consequence of life. Thus, given the time that it took to elaborate living and thinking systems I believe there is no mystery, it had to happen over the 3.5 to 4 billion years. I will end on a personal note; I was born in the exact year that the Miller experiment was published, and when I was 15, I was lucky enough to receive as a gift a book in French about biology in which the Stanley Miller experiment was explained, and it struck me at the time as being a very important step in biology. I actually regard it to be as important as the theory of Darwin on evolution or the deciphering of the genetic code. As a consequence I was extremely happy to read this book which highlights some refinements to the initial Miller experiment. So thank you to the Zhao team, and we can also congratulate Zhao for her environmental commitment (see references to this in her Wikipedia page at https://en.wikipedia.org/wiki/Zhao_Yufen).