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ON THE ORIGIN AND EARLY EVOLUTION OF BIOLOGICAL CATALYSIS AND OTHER STUDIES ON CHEMICAL EVOLUTION

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One of the lines of research in molecular evolution which we have developed for the past three years is related to the experimental and theoretical study of the origin and early evolution of biological catalysis. In an attempt to understand the nature of the first peptidic catalysts and coenzymes, we have achieved the non-enzymatic synthesis of the coenzymes ADPG, GDPG, and CDP-ethanolamine, under conditions considered to have been prevalent on the primitive Earth. We have also accomplished the prebiotic synthesis of histidine, as well as histidyl-histidine, and we have measured the enhancing effects of this catalytic dipeptide on the dephosphorylation of deoxyribonucleotide monophosphates, the hydrolysis of oligo A, and the oligomerization 2',3' cAMP.

On the theoretical side, we have reviewed and further developed the hypothesis that RNA preceded double-stranded DNA molecules as a reservoir of cellular genetic information. This has led us to undertake the study of extant RNA polymerases in an attempt to discover vestigial sequences preserved from early Archean times. So far, we have been able to develop an evolutionary classification of all extant cellular and viral RNA polymerases into a few families both on the basis of the amino acid sequences and function. Moreover, since the "RNA prior to DNA hypothesis" implies that reverse transcription is a very old phenomenon dating from the Archean Eon, we have analyzed the substrate specificities of several retroviral reverse transcriptases (including that of the AIDS virus) and discovered that under slightly modified laboratory conditions, these RNA dependent DNA polymerases behave as replicases, that is, as RNA dependent RNA polymerases.

In addition to the above research we have also continued our studies on the chemical evolution of organic compounds in the solar system and beyond. Hydrogenolysis by means of deuterium chloride of iron and other metal carbides found in meteorites has demonstrated the formation of aliphatic hydrocarbons from C_1 to C_7, an experimental finding which is in line with the recent observations of homonuclear linear carbon species in circumstellar clouds.

We have also suggested a simple mechanism for the high enrichment of deuterium found by other investigators in the amino acids of the Murchison meteorite, and we have developed arguments for the presence of anaerobic life in Europa in light of recent discussions about the possibility of a subsurface ocean in this satellite. These different lines of research in chemical evolution and exobiology have been carried out with the collaboration of G. Armangue, G. Fox, A. Mar, C. Marquez, T. Mills, and C. Shen.