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Systems Biology and the Origins of Life

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The problem of the origins of life, or of the origins of novel functions, cannot be understood without having recourse to the concept of system. Biochemical networks of present day cells can tentatively be considered models of prebiotic systems. These collective structures are, in fact, dynamic open systems that receive molecules from the external milieu, transform these molecules and release some of the corresponding products outside the system. It is no doubt of interest, in this perspective, to discuss some of the properties of such "simple" systems. The example that comes to mind is that of a two-substrate proteinoid reaction displaying random binding of its substrates, A and B.

A fundamental property of such a system is to display either the same probability, or different probabilities, depending on the protein has bound one ligand A for instance, or the same ligand A given that the protein has already bound ligand B. If the first probability, **p**(A), is larger than the second one, $p(A|B)$, this means that the interaction between A and B generates an information. This information, $i(A:B)$, is expressed as the difference between $h(A|B) = -\log p(A|B)$ and $h(A|B) = -\log p(A|B)$, namely, $i(A:B) = h(A) - h(A|B)$

If $i(A:B) < 0$, the interaction between A and B generates an information. Owing to their organization, many systems generate such information.

It then appears erroneous to think that the concepts of information and identity are specific to biological systems. In fact these concepts are specific to systems, whether biological or not. The emergence of a function, for instance catalysis, results in an increase of an energy level of the EAB complex (E being the catalyst) that becomes closer to the transition state of the reaction, thus leading to the enhancement of the chemical process. An important idea of systems biology is that a drift from quasi-equilibrium is, to a large extent, responsible for the production of information and enhancement of catalysis. Non-equilibrium of these simple systems must be an important aspect that leads to both self-organization and evolutionary processes. It thus appears that the basic ideas associated with the concept of system are extremely useful to approach the problems of the origins of life. In fact, the main features of living systems are: the ability to replicate; the ability to perceive signals and to appreciate whether their intensity increases or decreases; the ability to evolve by selection. All these characters of systems are the properties of living organisms. There is no doubt that the basic properties of systems are the very basis of biological problems.

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