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On the origin of biological information

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A living entity can be described as a complex adaptive system which differs from any, however complex, chemical structure by its capability of functional selforganization based on processing of information. If one asks where does this information come from and what is its primary semantics the answer is: information generates itself in feedback loops via replication and selection, the objective being "to be or not to be".

Three experimental studies referring to different levels of molecular organization are described that shed light on how genetic information originates:

(1) An automated serial transfer machine is used to adapt RNA to environmental constraints that strongly interfere with replication. The results obtained demonstrate how a non-trivial adaptation problem at the replicator level is solved via biassed mutation and selection.

(2) The infection mechanism of a virus inside its host cell is disected. The reaction scheme turns out to be highly regulated. It consists of a hypercyclic organization involving feedback loops of activation and inhibition. The results show how the genotype–phenotype dichotomy is overcome in nature.

(3) The fast evolution of viruses in their natural environment is studied with three examples of virus diseases: AIDS, influenza and poliomyelitis. The results uncover entirely different strategies of evolutionary adaptation, suggesting quite distinct counteracting antiviral strategies.

Although viruses, as we know them today, are presumably of a postbiotic origin, i.e. depending on the existence of proper hosts, the three examples well demonstrate nature's strategies of generating information by molecular evolution. The experiments were carried out with the help of automated, computer-controlled bioreactors, called "evolution machines", that may form the basis of a new "evolutionary biotechnology".

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