A Hypothesis on the Global Control of Genetic Activity in Relation to Biological Rhythms

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Current Hypothesis

Since the proposal of a hypothesis on genetic control by Jacob-Monod, it has been and is believed widely that "complicated network" composed with many key-lock interactions exhibits the role to perform the autonomous regulation of gene expression in living cells. Actually, seemingly nice reports of numerical simulation have appeared that such complex network can manipulate selective expression among number of genetic informations embedded in giant DNA, where many parameters on the network have been adjusted so as to reproduce the observation. However, it is to be mentioned that the model of complicated key-lock interaction is rather fragile to "noise", in other words robust control is difficult to be attained in such model. Generally, a certain gene has only one copy on genetic DNA in living cells. This indicates that the kinetic equation to describe the production rate of RNA and proteins can not be written by ordinary differential equation, i.e., the variables are not continuous real numbers but small natural numbers. Thus, it is obvious that we have to find another scenario to explain the robust control on number of genes, in addition to the current hypothesis of "complicated genetic network".

On/off transition of giant DNA in relation to global control of genetic activity

About a decade ago, it has become clear that giant DNA above the size of 100 kbp exhibits the characteristics to undergo large discrete transition between elongated coil and folded compact states. On the contrary, short DNA below the size of 1 kbp never shows such discrete change in the conformation. The discrete nature of the transition suggests that a number of genes exhibit on/off switching accompanied by the conformational transition. Actually, it has recently shown from the experiment of single DNA observation that transcriptional activity shows on/off switching on giant DNA molecules. Here, it is to be noted that such large discrete transition of DNA is caused by the change of environmental parameters, such as the concentrations of RNA, ATP, sodium ion, etc. Interesting to say, specific key-lock interaction can not induce such on/off change. It may be plausible that the discrete nature of DNA may concern with the mechanism of self-regulation of rhythmic change in the genetic activity on biological rhythmic phenomena.