Proc. Estonian Acad. Sci. Phys. Math., 1996, **45**, 4, 373–376
https://doi.org/10.3176/phys.math.1996.4.10

WHAT CAN A DNA MOLECULE AS A MESSAGE COMPRISE?

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Received 18 June 1996, accepted 28 August 1996

MIDA VÕIKS DNA MOLEKUL KUI SÕNUM SISALDADA? Karl K. REBANE

Key words: DNA sequencing, higher correlations, panspermia, disordered message.

The central problem of the grandiose international project "Man's genome" is to find reliable and fast methods to determine the sequence of nucleotides in a DNA molecule. The aim of this short note is to speculate about two aspects of DNA as a carrier and implementor of genetic information. First, besides the one-dimensional sequential order, some subtler features can play a certain role. Second, if a DNA-like molecule was the messenger of panspermia, what kind of information it could have carried and what the probably most reasonable way was to code it.

I

The sequence of nucleotides prescribes via a few intermediate steps the structure of the proteins and in the end the whole structure of an organism. This actually means that the formation of an organism is completely reduced to chemistry. Further, as far as the functions are prescribed by the structure and the structure is built up just to perform the organism's functions, even the functioning of every organism seems to be reduced to chemistry.

Actually, the functions and also the realization of the DNA's prescriptions are to some extent caused and controlled by the environment, depending on its state and changes. Nevertheless, the chemical information stored in DNA and the chains of chemical processes triggered by it are essential. Chemistry seems to guarantee and perform all the potentials of an organism.

We have good reason to believe that the conventional chemical structure is not all that DNA comprises. There should be something out and above chemistry (also above nowadays physics and biology), something that is decisive and especially clearly displayed in the case of highly developed organisms, e.g. human beings.

In my understanding one of the essential points should be the free will. If we agree with Erwin Schrödinger [1] that free will does exist (I as a physicist agree [2, 3]), the difficulty in reducing the existence, the individual features, and the evolution of the most important property of the human spirit – the free will – to the sequence of nucleotides becomes clearly displayed.

Returning to the chemical structure, we can ask: Why should solely the sequence itself (i.e. the one-dimensional order of "seat numbers" in the chain) carry essential information? Why cannot the correlations of the spatial distances between the nucleotides also determine something essential chemically or otherwise? What about the matching and even small unmatching of energy resonances? What about the most important feature of life – the inhomogeneity of spatial and frequency domains? Folding has already been found important. Why has Nature completely neglected the options to store, process, and transfer information via DNA in a manner Nature has done using neural networks or optics has done in holography? These methods are parallel and fast, able to avoid and compensate errors, able to learn. Why are there so many "information-empty" sections in DNA?

My approach to the problem is that of a physicist and thus I would like to have it put as a hierarchy of carrying information structures. The first approximation (and in some sense the most basic one) is the one-dimensional order of numbered seats for nucleotides. However, the potential of a certain nucleotide to start a series of reactions and the course of the line of reactions itself depends not only on the kind of the nucleotide but also on other factors, e.g. the state of the environment: if the constituent needed for the next step of the reaction is absent in the vicinity, the main line will be interrupted and a different one started. The other nucleotides in the nearby seats of DNA and also those far off by numeration but relatively close spatially because of folding or some other reason (DNA in its natural state is far from being a straight line) should also somewhat influence the *rate* of the reactions prescribed by the nucleotide or a group of them. If these second- and higher-order approximations of the distribution of nucleotides do not even influence the final result, they can change a little the chemical potentials of nucleotides and in this way affect the reaction rates. In the conditions of repeated cycles of competition even very small differences are significant. Thus the higher-order effects can assist in deciding which prescriptions are realized fast, which slow, and which are not realized at all.

The approach of physics to that kind of problem is to consider the first, second, etc. correlations in the distribution of nucleotides along a DNA molecule, also over their spectrum of frequencies (eigenfrequencies). From the more general point of view we cannot exclude even the possibility that some essential features or potential features are coded in even subtler ways. (What about the free will?)

Selection by Nature in the simplest understanding means throwing mercilessly away everything that has failed to find and keep its place (ecological niche) in the (changing) environment, to stay alive in the struggle for life. This line of Nature's behaviour has stimulated the creation of sophisticated ways for finding and keeping the ecological niche: instincts, intellect, learning, etc. Why should not we suppose that some of these ways are implemented in the information stored at the level of DNA? How are the instincts inherited? The subtle properties of character and mind, intellect?

II

One possible way to check the hypothesis of panspermia – the idea that life was brought to Earth from the outer space [4] – is to look for the (relict) traces of space travel in the structure of nowadays DNA [5, 6]. What could be the features of such a DNA-like molecule, or a body of them, "designed" to carry a life-creating message during a long journey through the cold and full of various radiations space to a new world to start life in it? Thereby the conditions – physical, chemical, geological – of the world are not known.

A simple and reasonable answer could be that the message should not have a fixed high-order structure. On the contrary, it has to be a quite highly disordered one, but comprise potentials to trigger the growth of a great variety of expanding structures. For example, let the messenger be a bulk of nucleotide-like molecules having different sequences of nucleotides, not obligatorily carrying information on some design for biologically important molecules. This bulk should be able to start a great variety of lines of chemical reactions. The possibility and course of the latter depend on the environment into which the messenger happens to be implemented. The lines matching best the conditions given by the new environment and also those, posed by the other implemented reactions, survive. The initial sequences of nucleotides or nucleotide-like links in a DNA-like molecule have to be different, compose a broad inhomogeneous distribution to guarantee the flexibility necessary to match (and also change) the conditions in the new world, i.e. to have as high probability as possible to comprise at least one sequence able to start life in the new world.

The hard selection governed by both the environment and the potentials of the messenger let survive only these reactions and processes which happen to match the requirements posed on them by the both factors. If the conditions are favourable and the potential of the messenger sufficiently large, a new kind of life can be started. Of course, large amounts of negentropy (e.g. chemical free energy in the substances at the new world's surface or/and "solar" radiation) are needed to keep the multiplication reactions and selection processes going.

Thus, an initially largely disordered (inhomogeneous) structure, capable of starting a great variety of *appropriate* "probe" reaction lines, is the one favourable for a "panspermia message".

Note that the inhomogeneity is a very general and important feature of the structure and processes of life. The first advantage in the case of panspermia is the ability of an inhomogeneous body of species to compromise with a new environment and utilize its resources. Secondly, as compared to a highly-ordered structure (e.g. DNA of a fixed structure), that kind of body of species can be orders of magnitude less sensitive to the perturbations and changes created during the long travel in space (by irradiation, etc.). A change in one component of a well disordered nearly random mixture of a large body of DNA-like components different by sequence has much probability of resulting in a component suitable to belong to the body of the components of the message. Such kind of changes do not change potentials of the message.

ACKNOWLEDGEMENTS

This work was supported in part by the Estonian Science Foundation grant No. 2490 and in part by the International Centre of Scientific Culture – World Laboratory.

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