

DOI: 10.1070/PU2001v044n10ABEH001009

On D S Chernavskii's paper "The origin of life and thinking from the viewpoint of modern physics"¹

The first part of D S Chernavskii's paper examines the reason why the genetic code in all living creatures is the same. The author rejects the obvious reason that the given combination of nucleotides has proved to be the most effective and stable. He suggests a different reason, namely, that of the varieties of nucleotide chains (NCs) coding a given amino acid, in every case, i.e. for every amino acid, the NC with the largest initial concentration triumphed. (Here I depart from the author's terminology, since he speaks of the concentration of hypercycles, though a hypercycle is a process, so it is inaccurate, if not to say more, to speak of a concentration of processes.) To prove his proposition, the author set up a system of kinetic equations that describe the time dependence of the concentration of each variety of NCs and take into consideration the self-reproduction of NCs and their interaction with each other. At first, for each variety of NCs he introduces individual parameters that characterize their chemical properties, but then ignores the differences between them, leaving their initial concentration as the only distinction. He thereby declares in advance that the chemical properties of the reacting substances have a minimal effect on the course of the reaction. But the paper offers no evidence that the effect is indeed so small. It does not even indicate the criterion of smallness, though without this all computations that ignore the chemical differences lose their validity.

The second logical mistake is that the author's system of equations disregards the dependence of concentrations on coordinates. Hence, the system is applicable only when sufficiently intense mixing occurs in the medium. But there is no evidence in the paper that the mixing was so intense. Nor is there any criterion of sufficiency of intensiveness, i.e. the basis on which to build a proof is lacking. Consequently, the author's assertion that the decisive role of the NC initial concentration ensured one genetic code for all living creatures on the Earth is left suspended in midair.

M V Fok

¹ Chernavskii D S *Usp. Fiz. Nauk* **170** 158 (2000) [*Phys. Usp.* **43** 151 (2000)] (further referred to as Ref. [1]).

D S Chernavskii P N Lebedev Physics Institute,
Russian Academy of Sciences
Leninskii prosp. 53, 117924 Moscow, Russian Federation
Tel. (7-095) 132-6296. E-mail: chernav@lpi.ru

M V Fok P N Lebedev Physics Institute, Russian Academy of Sciences
Leninskii prosp. 53, 117924 Moscow, Russian Federation
Tel. (7-095) 132-6292

Received 26 June 2001

Uspekhi Fizicheskikh Nauk **171** (10) 1147 (2001)

Translated by E Yankovsky; edited by A Radzig

DOI: 10.1070/PU2001v044n10ABEH001008

Reply to the letter by M V Fok received by the *Physics-Uspekhi* Editorial Board

The letter discusses two points regarding which I (see Ref. [1]), in the opinion of M V Fok, made 'mistakes of logic'.

The first is concerned with the choice of a unified code.

The 'obvious' reason mentioned in Fok's letter is not at all obvious in reality. Experts continue to discuss this topic, as can be seen in my paper [1]. The paper examines a version in which the choice of code depends not on *a priori* advantages but on spontaneous breaking of symmetry, i.e. on the instability in the symmetric state. For this the paper examines an extreme (symmetric) version of the model. The main result is that even in this case the unified code is chosen (not selected) in the sense of the original paper.

A similar model is used to choose a version of biological asymmetry (Section 3 in Ref. [1]).

Spontaneous breaking of symmetry is well known to experts in chemical, physical, and biological kinetics. It is also known that small distinctions that break the initial symmetry cannot serve as a 'reason' for the ultimate choice if the role of these distinctions is small. The measure of smallness depends on the properties of the specific process (among other things, on 'noise' caused in the given case by coding mistakes). In view of this the code, too, is chosen at random and is not necessarily 'optimal'.

These issues are considered, in particular, in Section 3 of paper [1]. There is also mention of the possible different versions of the code in Section 2.3. Needless to say, this is done briefly owing to the limited space. Anyone wishing to delve more deeply into this problem can do so by turning to the list of references (including papers whose authors take an alternative view).

The second 'logical mistake', according to the author of the letter, has to do with the fact that the model cited in paper [1] disregards the effect of migration in space. M V Fok argues by way of criticism that in the event of spontaneous breaking of symmetry other variants of the code would be preserved.

Allow me to say that a distributed-in-space model of code choice has been constructed and studied. The paper [1] does not include it for lack of space but the necessary references are given. These works made it clear that the choice of code in space goes on genuinely for a long time but that ever since the biosphere has existed one version has crowded out the rest almost completely. Other versions could remain and indeed have remained in organelles: chloroplasts and mitochondria. From this it follows, let it be said, that the choice of code went on for a long time, right up until photosynthesizing and breathing organisms appeared. The latter had already left the sea for land and could move with the air flows.

The organelles referred to are the result of the symbiosis of a cell capable of assimilating light (chloroplasts) or oxygen (mitochondria) and as a result synthesizing ATP, and a cell capable of utilizing ATP. These organelles constitute biological insulators in the sense that their genetic material does not mix with the material of the host cell.