Scientific session of the Division of General Physics and Astronomy and Division of Nuclear Physics of the Academy of Sciences of the USSR (27–28 April 1983)

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A joint scientific session of the Division of General Physics and Astronomy and the Division of Nuclear Physics of the USSR Academy of Sciences was held on April 27 and 28, 1983 at the S. I. Vavilov Institute of Physical Problems of the USSR Academy of Sciences. The following reports were presented at the session:

April 27

1. *R. A. Syunyaev,* Compton scattering in astrophysics (intergalactic gas, accretion disks around black holes, x-ray pulsars).

2. *Ya. É. Éĭnasto,* Observable large-scale structure of the universe.

April 28

3. *M. V. Vol'kenshteĭn,* The essence of biological evolution.

4. *O. B. Ptitsyn,* Physical principles of protein structures.

5. *A. A. Vazina,* Liquid crystals and biological mobility.

A brief summary of three of the reports is published below.

M. V. Vol'kenshteĭn, *The essence of biological evolution.* It is mistaken to believe that the Darwinian theory of evolution is obsolete, since there is neither enough material nor time for the appearance of the present biosphere. Biological evolution is a specific manifestation of the development of the universe, and its phenomenological interpretation consists of examining a dissipative system far from equilibrium, maintained by an outflow of entropy. The adequacy of material for evolution is determined by the extensive variability in any population and the high content of heterozygotes, which represent mutant genotypes. It is believed that only a single directing factor is operative in evolution: natural selection. In reality, there is a second, no less, if not more, powerful factor: the completed structural type and development of the organism. Evolution has a directed and irreversible nature. Genetically programmed reading of positional information, i.e., the regulator action of genes, is determining. Not only the structure of the functional molecules (primarily proteins), but also the location and time of their action are important. In view of the directedness of evolution, by no means all traits have adaptive value. The usual question in biology, viz., "Why?", by no means always has an answer.

Evolutionary theory distinguishes micro- and macroevolution. The former indicates accumulation of small changes in a population and the second means the appearance of new species and higher order taxons. It can be shown that speciation and macroevolutionary processes have the nature of phase transitions. These transitions can be more or less sharp and, correspondingly, the concepts of point equilibrium and phyletic gradualism are used in biological theory. Apparently, both occur. At the molecular level, evolution is manifested in the difference in the composition and sequence of amino acid residues in homologous proteins. Based on this, it is possible to construct evolutionary trees. It may be considered as proven that many evolutionary substi-

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tutions in the nucleic acids and proteins are neutral and are not subject to natural selection, acting at the level of phenotypes. The physical significance of this neutralistic theory of evolution, proposed by Kimura, lies in the nonunique, degenerate correspondence of the primary structure of the protein and its biological function. The neutral character of many point mutations accelerates evolution. The established structural type of the protein does not change with neutral mutations. The neutralistic theory is also justified by the "noise resistance" of the genetic code, which determines the high probability of the substitution of amino acids by amino acids whose properties are very similar.

There is also a fallacy in the idea of the great stability of genes. In recent years, a set of phenomena indicating the dynamic properties of genes and their mobility have been discovered and studied. A number of factors, including viruses, are known to transmit genetic material. This also greatly accelerates evolution.

It is instructive to examine evolution with the help of the concepts of information theory. In biology, the content or value of information is important. This concept cannot be represented in a universal form: the value of a message is determined only by the consequences of its reception. Reception of information is a nonequilibrium, irreversible process involving a transition from a less stable state to a more stable state. The creation of new information, which always occurs in evolution, is an irreversible memorizing of the random selection.

Using the definition of value as indispensibility at a given level of reception, it can be shown that value increases during the course of both individual and evolutionary development. In evolution, the capability for selection of valuable information increases simultaneously.

It is customary to talk about progress in evolution and about an increase in complexity. This concept must be defined. A reasonable definition of the complexity of a message is the number of bits in a minimum program generating the message (Kolmogorov). It is clear that the concept of complexity and indispensibility are close, however, the second concept is richer, since complexity refers to the message as a whole, while indispensibility also characterizes its elements; complexity expresses structure, while indispensibility also expresses function. In phenomena of evolutionary simplification (with a transition to a parasitic life form, for example), indispensibility and value increase.

Thus evolution is directed and irreversible. Apparently, there has been enough time. It is still difficult to construct a general quantitative model theory, but particular models are being developed successfully. There is no basis for believing that some kind of new physics will be required to understand evolution.