ABSTRACT BOOK

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THE ROLE OF PHYSICAL PLASMA IN SELFORGANIZATION IN BIOSYSTEMS

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It is well known that in many physical and chemical systems fluxes of energy and/or mass lead to the origin of organized spatio-temporal structures from chaotic states of components. Oscillating chemical reactions, quantum generators, nonstabilities in liquids and plasma are only some examples of the processes belonging to this category.

Physical plasma is unique among other states of matter by the crucial role played in it by various selforganization processes. If the weak coupling criterion is satisfied by the electrically charged mobile particles, the state of any particle in the ensemble depends on other ones, and the state of a particular charge carrier depends on the state of the entire system. In consequence of it every type of action exerted on any part of the system or any internal change of local electrical/magnetical properties (e.g. change in concentration) induces changes in the entire system by various mechanisms of coupling.

It is therefore no wonder that physical plasma has been considered as a magnetically and electrically selforganizing substrate of basic processes in living systems. Yet, this possibility has continued to be open to various questions and criticism. In this presentation some arguments for the existence and role of plasma in biosystems will be considered in order to show, that this hypothesis is quite attractive and reasonable.

To answer the question about the possible occurrence of plasma in any biosystems, one of two basic branches of investigative strategies may be followed. The first one consists of attempts at experimental finding plasma-unique phenomena in biosystems. They may aim at, e.g. finding plasma-resonance like phenomena or "decoupling" of the plasma state in biosystems, resulting in disturbing or even abolishing life processes. It is worth mentioning in passing that at least some types of effects found in the millimeter-wave resonance experiments may fall in this category.

The other branch of strategy consists in showing that sufficient criteria for the existence of physical plasma are met in biosystems. Therefore, when considering the possible occurrence of plasma in any system several sets of its properties must be taken into account and several basic questions must be answered as: Do mobile charged particles occur in the system? What are their characteristics, i. e.: concentration, mass, charge, and mean kinetic energy? What are the properties of the medium in which they move and interact with one another?

As far as the mobile particles acting as basic components of plasma in biostuctures are concerned, electrons and/or holes may occur in biomembranes, cytoskeleton, extracellular tubules as well as in organelles (chloroplasts, mitochondria). Therefore, this basic condition for plasma in biostructures is satisfied. The concentration of these particles has been estimated to be of the order of 10^{23}-10^{25} m^{-3}. Therefore it seems reasonable to go to more details in characterizing these particles.

The absolute temperature that may be taken into consideration (assuming the particles and their background are in thermodynamic equilibrium) is the temperature of survival of an organism. Yet there is quite possible, that the mentioned particles may not be in equilibrium with the lattice, at least in short periods of time after their generation or excitation (e.g. by light, exoergic chemical reactions). In that case, the temperature of electrons may exceed that of thermal equilibrium, may be by more than by one order of magnitude.

As the relationship between the mean kinetic energy of particles and the energy of their mutual electrostatic interaction (V_k/V_p) is of crucial importance, possible values of permeability of the medium should also be taken into consideration. In this connection two lines of arguments may be applied. According to the first one, the biological medium may be considered as a linear dielectric. The span of possible values of dielectric constant may be limited by the values 2 and 81. However, if the medium were nonlinear, dielectric constant may reach the values of 10^3 or even more. Another physical parameter which plays a role in the above mentioned relation is the effective mass of particles. It may be taken as equal to that of the one in free space (m_o). Yet,it may also be different from it. It does not seems unreasonable to admit the mass equal 0,1 m_o as the lower bound and 10^3 as the upper one.

As far as the properties of the medium, the electrons move in, are concerned, attention should be paid to the linear dimension of the potential seat of plasma, its anisotropy, and linearity/nonlinearity of dielectric properties.

As biostructures are extremely nonhomogeneous media, therefore it should be not overlooked that the conditions sufficient for the existence of plasma may be realized only in some spaces and/or time intervals. In that case the lower bound to the values of the linear size may lay in vicinity of 10^{-8} m (the typical thickness of the structures spanning biomembranes) and 10^{-5} (size of a typical cell) as the upper one. As anisotropy and rapid changes of local properties seem also be an intrinsic characteristics of biomaterial they should be taken into account in a more precise study. Here these circumstances are only hinted upon, but not paid more attention.

One group of the most important processes taking place in biosystems are catalytical reactions. In these processes the translocation of charge carriers and rotations of polar molecules of water in their surrounding are involved. In enzyme macromolecules there occur domains where more or less delocalized π-electrons create 1, 2 or 3-dimensional conductivity paths of various values of conductivity. These electrons fulfill the conditions necessary for the existence of plasma. Therefore the excitation of plasma oscillations would possible (as is in fullerens or other organic conductors). These oscillations may play the role of a factor that organizes the processes in biosystems.

Cytochrome c3 (one of the smallest known cytochromes) of the bacterium *Desulfovibrio vulgaris* (Miyazaki strain) may be taken as an example. It contains four hemes, 107 aminoacid residues, 3.3 x 3.9 x 3.4 nm in size and of about 14000 daltons in molecular weight. Electrical conductivity of it is close to that of semi-metals. If in this system several hundred electrons occur, then the volume concentration of electrons may be quite high, approaching about 10^{28} m^{-3}. Various plasma characteristics (e.g. ω_p, T) may be of significance to specificity and selectivity of enzymatic processes and mechanisms of various types of enzymatic processes may have their "common denominator" in energetic and spatio-temporal characteristics of plasma domains in enzymatic systems.

Granted that the existence of physical plasma in a biosystem is a necessary condition for sustaining its life, two important consequences may be drawn and experimentally tested. The first one pertains the deep-physical determination of the level of the vitality of a biosystem. The other one – the continuation of the life itself. In this context, vitality may be measured by the degree the set of mobile particles fulfill the conditions for the existence of the plasma state. And finally, death of a biosystem may be the consequence of "decoupling" of plasma (i.e. breaking one or more of the conditions for its existence) in one its critical subsystems.