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Biophysical Energy Transfer Mechanisms in Living Systems: The Basis of Life Processes.

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Abstract

The main reservoir of free energy in biological processes is electron-excited states of complex molecular systems. Communities of delocalized excited π-electrons in protein macromolecules are the basis of this energy reservoir. Specific structural-protein complexes within the mass of the skin provide channels of heightened electron conductivity, measured at acupuncture points on the surface. Stimulated impulse emissions from the skin are also developed mainly by transport of delocalized π-electrons. Stimulated by high voltage impulses, optical emissions, with amplification in gaseous discharge, are registered by optical sensors (Gas Discharge Visualization - GDV). This quantum model supports an argument that GDV techniques provide indirect judgment about the level of energy resources at the molecular level of functioning in structural-protein complexes. Several years of GDV research have provided clinical correlations with well-accepted physiological parameters. Gas Discharge Visualization methods for investigating human functional states, by assessing electro-optical parameters of the skin, are based on the registration of physical processes emerging from electron components of tissue conductivity.

Introduction

A precise definition of what we understand as "Energy" in relation to biological systems is a critical requirement, if we are to successfully incorporate into a Western scientific paradigm those complementary medicine approaches that are based on the Oriental notion of "energy transfer." Misuse of the term "energy" leads to misunderstanding and subconscious rejection of useful, practical applications. The latest biophysical quantum concepts can, however, provide a conceptual understanding of the “energy transfer” mechanisms in biological systems at the organism level. These concepts create a basis for the biophysical explanation of Oriental notions of energy meridians, channels and acupuncture points.

The methods for investigating human functional states by assessing electro-optical parameters of the skin can be divided into two conditional groups, according to the character of biophysical processes involved. “Slow” methods, with measurement times of more than 1 second, make up the first group. Under the influence of applied potentials, ion-depolarized currents are stimulated in the tissues and the ion component mainly contributes to the measured signal [Tiller, 1988]. The second group of “quick” methods, measurement times of less than 100 msec, are based on the registration of physical processes, emerging from the electron components of tissue conductivity. These processes are described mainly by quantum-mechanical models. They might therefore be denoted as methods of quantum biophysics. Such methods include techniques for registration of stimulated and self-luminescence, as well as the method of stimulated electron emission with amplification in gaseous discharge (Gas Discharge Visualization). Before discussing the assessment processes, let us first explore the electron mechanisms in biophysical processes in some detail.

Electron scheme of life

"I'm deeply sure that we will never be able to understand the essence of life, if we restrict ourselves to the molecular level… A surprising subtlety of biological reactions is stipulated by the mobility of electrons and can be explained only from the position of quantum mechanics."

A. Szent-Györgyi, 1968

The main reservoir of free energy in biological processes is electron-excited states of complex molecular systems. When physical or mental work is done, electrons distributed in protein structures are transported within their given place and provide the process of oxidative phosphorylation, i.e. the energy supply for local system functioning. A part of these electron excited states is expended for the support of current energy resources in the organism. A part can also be reserved for the future, as in lasers after absorption of a pump pulse. Communities of delocalized excited π-electrons within protein macromolecules are the basis of this energy reservoir. The organism forms an electron "energy depot," at some moments requiring great resources or rapid flowing under conditions of extra-high loads -- typical, for example, of professional sport.

It can be argued that the formation of specific structural-protein complexes within the mass of epidermis and dermis of the skin provides channels of heightened electron conductivity, which are experimentally measured as electrical conductance at acupuncture points on the surface. Stimulated impulse emission from the skin is also developed mainly by transport of delocalized π-electrons, realized in electrically non-conducting tissue by quantum electron tunnel mechanisms. This proposition allows an assumption that the GDV technique provides indirect judgment about the level of energy resources at the molecular level of functioning in structural-protein complexes.

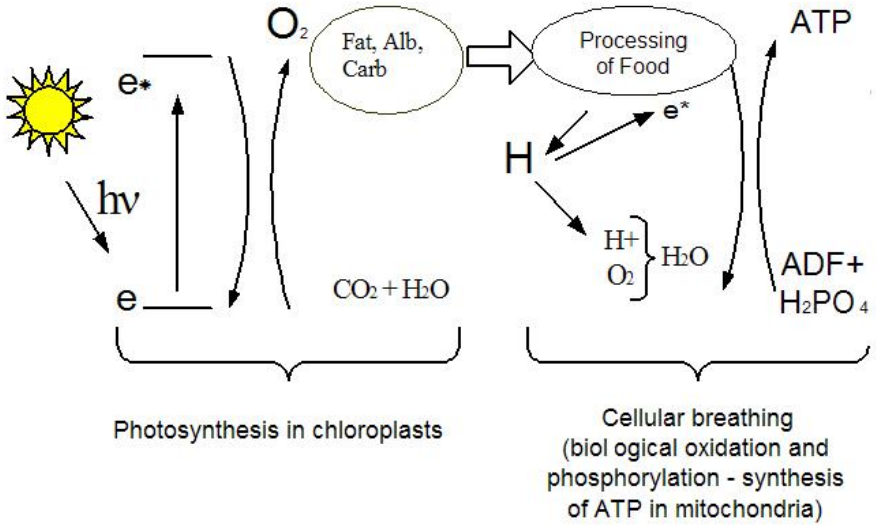

FIG. 1. Electron scheme of life. [Samoylov, 2001]

Several years of GDV research have provided clinical correlations that position GDV measures together with well-accepted physiological parameters. Post-surgery recovery progress is correlated with GDV parameters. Research on a large contingent of top athletes demonstrates complimentary dependence of GDV parameters both on actual psychophysical potential for top athletes and on the ACE genotype for the angiotensen converting enzyme, which determines a predisposition to top achievements in endurance. GDV parameters of sportsmen provide an independent diagnostic measure of psychophysical reserves in athletes, directly characterizing their actual psychomotor potential.

The circulation and transformation of energy in biological systems provides the basis of life on Earth. This process – the electron scheme of life – might be represented as the following scheme [Samoylov, 1986, 2001] (FIG.1). Photons of sunlight are absorbed by the molecules of chlorophyll, concentrated in the membranes of chloroplasts of organelles of green plants. Absorbing the light, electrons of chlorophylls obtain supplementary energy and transform from one excited state to the other, using a well-ordered organization of the albumin-chlorophyll complex called photo-systems (PS). The excited electron acquires a capability to overcome electrostatic repulsion rather than expending energy in thermal transformation of the molecules. Although the substance next to it has a

higher electron potential than the chlorophyll, the photo-system delivers an excited electron into this substance.

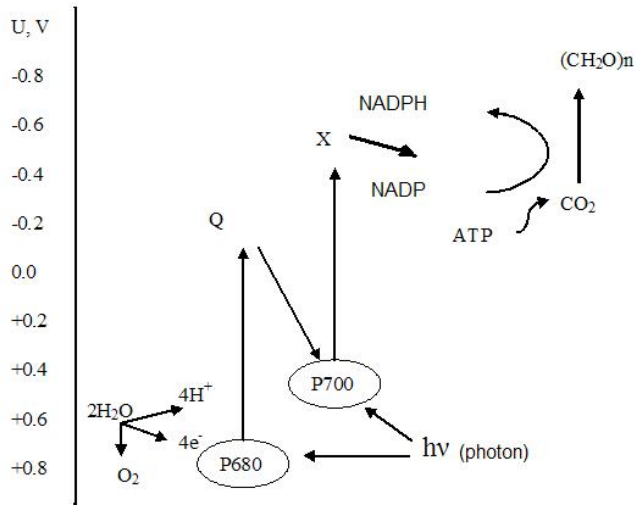

FIG.2. Intermolecular transfer of electrons in the membranes of chloroplasts under photosynthesis. U – standard reconstruction potentials in Volts; P680 and P700 – chlorophyll, maximally absorbing light with wave-lengths 680 nm and 700 nm; X – ferredoxin albumen.

After the loss of its electron, the chlorophyll has a free electron vacancy. And it takes away an electron from the surrounding molecules. Substances with electrons having smaller energy compared to the electrons of chlorophyll will serve as donors. Water is a key electron donor (FIG.2).

The photo-system oxidizes the water to molecular oxygen, taking away the electron from it. Thus, the atmosphere of the Earth is constantly being enriched with oxygen.

When a mobile electron is transferred along the chain of structurally interconnected macromolecules, it provides its energy to anabolic and catabolic processes in the plants, and, under proper conditions, in animals. According to the modern notions [Samoylov, 2001; Rubin, 1999], intermolecular transfer of excited electrons proceeds in compliance with the tunnel effect mechanism in strong electrical fields. This field is created by electrical potentials at the cellular boundaries.

Chlorophyll serves as a transitional step in a potential pitfall between the donor and the acceptor of electrons. Chlorophyll accepts electrons from the donor with low energy level and excites them so that they can pass to a substance with a higher electron potential than the donor, at the expense of sun energy. Although it is a multi-step process, this is the only light reaction in the process of photosynthesis. Further autotrophic biosynthetic reactions do not need light. They take place in green plants due to the energy contained in the electrons belonging to NADPH and ATP. As a result of the colossal inflow of electrons from carbon dioxide, water, nitrates, sulfates and other comparatively simple substances, highly complex molecular compounds are created: carbohydrates, albumin, fats, and nucleic acids.

These substances serve as the main nutrients for heterotrophs. In the course of catabolic processes, also provided with electron-transport systems, approximately the same quantity of electrons is released as was captured by organic substances under photosynthesis. The electrons released through catabolism are transferred to molecular oxygen by the respiratory chain of mitochondria (see FIG. 1). Here the oxidation is associated with phosphorylation – synthesis of ATP by attaching the remainder of phosphoric acid to ATP (i.e. ATP phosphorylation). This provides an energy supply for all the processes of vital activity in animals and human beings.

Being in the cell, biomolecules “live” by exchanging energy and electrical charges and, hence, information, provided by a developed system of delocalized π-electrons. Delocalization means that the collection of π- electrons is distributed in a certain way over the entire structure of a molecular complex. This enables the π-electrons not only to migrate within the limits of their own molecule, but also to transfer from one molecule to another, if the molecules are structurally united into ensembles. The phenomenon of intermolecular transfer was discovered by J. Weiss in 1942, and the quantum-mechanical model of this process was developed in 1952-1964 by R.S. Mulliken.

The most important mission of π-electrons in biological processes derives not only from their delocalization, but also from the peculiarities of their energy status. The difference between the en-

ergies of the main and the excited state is much smaller for π-electrons than for σ-electrons (local electrons) and is approximately equal to the photon energy hν.

Because this small difference between the ground state and the excited state is equal to the photon energy, these delocalized π-electrons can accumulate sun energy. Thus the entire energy supply of biological systems is provided by them. Therefore, π-electrons may be named "electrons of life" [Samoylov, 2001].

By comparing the scales of reduction potentials for components in photosynthesis systems and respiratory chains, it becomes obvious that the sun energy accumulated by π-electrons under photosynthesis is mainly provided to cellular "breathing" (ATP synthesis). Thus, at the expense of absorbing two photons in the chloroplast, π-electrons are transferred from P680 to ferredoxin (FIG. 2), increasing their energy by approximately 241 kJoule/mole. A small part of this energy is spent during the transfer of π-electrons from ferredoxin to NADPH. As a result, substances are synthesized, which then become the food for heterotrophs and turn into substrates of cellular breathing. At the beginning of a respiratory chain, the resource of free energy of π-electrons provides 220 kJoule/mole. Therefore, prior energy decrease for the π-electrons has been only 20 kJoule/mole. More than 90% of sun energy reserved by π-electrons in the green plants is transferred by them to the respiratory chain of mitochondria in animals and human beings.

Water is the end product of oxidation-reduction reactions in the respiratory chain of mitochondria. It possesses the least free energy of all biologically active molecules. It is said that with water the organism isolates electrons depleted of energy during the processes of vital activity. As a matter of fact, the reserve of energy in water is by no means zero, but all the energy is contained in σ-links and can't be used for chemical transformations in the organism subject to the body temperatures and other physical-chemical parameters of animals and human beings. In this regard, water chemical activity is taken as the reference point (zero level) for the scale of chemical activity.

Among all the biologically important substances, water possesses the highest ionizing potential – 12.56 eV. All molecules of the biosphere have ionizing potentials lower than this value. The range of values is approximately within 1 eV (from 11.3 to 12.56 eV).

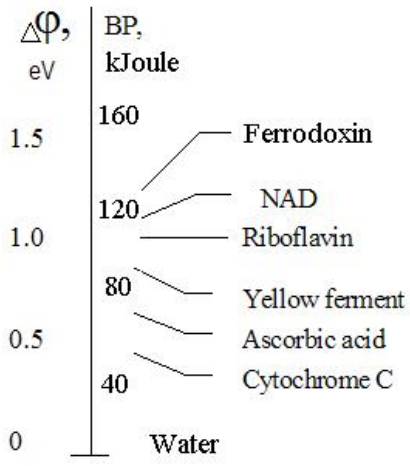

FIG. 3. Scales of ionizing potentials and biopotentials (according to Szent-Györgyi, 1968)

If we take the ionizing potential of water as the reference point of reactivity for the biosphere, we can build a scale of biopotentials (FIG. 3). The biopotential of each organic substance has a particular value – corresponding to the energy released when this compound is oxidized to water.

Dimesion BP (biopotential) in Figure 3 is the dimension of free energy of the corresponding substances (in kcal). The scale on the left (represented in eV -- electron Volts) shows the difference in ionization potential for each substance, between the redox-pair of that molecule and the standard redox-pair O_2/H_2O. Translation between the left scale of ionization potential differences and the right scale of biopotentials is based on the Faraday constant, using 1 eV = 1.6 10^{-19} Joule. (The Faraday constant represents the amount of electric charge carried by 1 mole of electrons, i.e. Avogadro's number.) By absorbing photons, electrons can reach the maximum biopotential in the photosystems of plants. From this high energy level they discretely decrease (step by step) to the lowest energy level in the biosphere – the level of water. The energy returned by electrons at every step of this ladder is turned into the energy of chemical

bonds and thus drives the life of animals and plants. Electrons of water are bound by the plants, and cellular breathing gives birth to the water again. This process produces electron circulation in the biosphere, and our sun is the source. Life is based on absorption and processing of light quanta. Electron excited states are the basis for energy storage in biological systems. Transfer of these states (but not electrons themselves) provides mechanisms for "energy" transfer along biological tissues, which may be associated with meridian flow.

The cellular breathing system's membrane organization is important for oxidative phosphorylation. Organization on the membrane provides a precise order for the mutual arrangement of molecules, which form a cascading electron-transport chain and a whole molecular ensemble for coupling of oxidation and phosphorylation processes. As demonstrated by E. Raker, some carriers are concentrated on the outer side of interior mitochondrial membranes, other carriers are concentrated on the inner side, a third group (cytochrome-c-oxidase) penetrate through the membrane, and the proton pump not only penetrates all the membrane, but also extends into the matrix. These vector structural-topographic peculiarities of molecular organization at the inner membrane of mitochondria are a necessary condition for the transformation of the energy from excited π-electrons into the free energy of the end phosphate link ATP.

Another class of processes being the source and reservoir of free energy in the organism are oxidizing processes, which take place in the organism with the participation of active forms of oxygen (AFO). AFO are highly reactive chemical particles, which include free radicals containing oxygen ($O_2^{-}\bullet$, $HO_2\bullet$, $HO\bullet$, $NO\bullet$, $ROO\bullet$), as well as molecules capable of easy production of free radicals (singlet oxygen, O_3, ONOOH, HOCl, H_2O_2, ROOH, ROOR). Most publications on AFO discuss questions on the pathogenic effect of AFO, as for a long time it was supposed that AFO appeared in the organism when normal metabolism was disturbed, and in the course of chain reactions initiated by free radicals, molecular components of a cell were damaged.

However, now it has become clear that practically all cells have ferments generating superoxide and the process of normal physiological cell reactions correlate with the increase of production of AFO [e.g. Sauer et al.., 2001]. AFO are also generated in the course of non-fermentative reactions constantly taking place in the organism [Mullarkey, et al., 1990]. Production of AFO requires minimally 10-15% of oxygen during breathing when a human or an animal is in the state of rest. If activity increases, this part grows significantly [Vlessis, et al., 1995]. In addition, stationary levels of AFO in the organs and tissues is very low in normal state from a general prevalence of powerful fermentative and non-fermentative systems destroying them. The question: Why an organism produces AFO so intensively in order to slowly get rid of them? - hasn't yet been extensively discussed.

It was found that adequate reactions of cells to hormones, neuromediators, cytokines, and physical factors (light, temperature, mechanical effects) require certain contents of AFO in the medium. AFO can stimulate the same reactions as developed under the influence of bioregulatory molecules in the cells: from activation or reversible inhibition of fermentative systems to regulation of activity of a genome. Biological activity of the so-called air ions, exerting pronounced therapeutic effect on a wide range of infectious and non-infectious diseases [Chizhevsky, 1999], is allowed by the fact that they represent free radicals ($O_2^{-}\bullet$) [Goldstein, 1992]. Other AFO are increasingly applied in therapy: ozone and hydrogen peroxide.

In recent years important results have been obtained by the group at Moscow State University led by professor V.L. Voeikov (2001) [Novikov et al, 2001]. It has been determined that reactions with the participation of AFO continuously take place in blood. This conclusion was based on a large amount of experimental data on the investigation of extra weak photon emission from human whole undiluted blood. Electron-excited states (EES) are generated in the course of these reactions. Analogous processes might be initiated in model water systems, containing amino acids and components, facilitating slow oxidation of amino acids under conditions close to physiological. Energy of electron excitation might radiatively and non-radiatively migrate in water model systems and in blood and might be used as activation energy for the intensification of processes causing electron-excited states, particularly at the expense of induction of degenerated branching of chains.

Processes with the participation of AFO taking place in blood and in water systems demonstrate signs of self-organization. These signs are represented in the oscillatory character of AFO and resistance to the influence of intensive external factors; however, sensitivity to the influence by factors of low and extra low intensiveness is kept. This thesis is the basis for an explanation of many effects used in modern low-intensive therapy.

Results obtained by V.L. Voeykov demonstrate another mechanism of generation and utilization of electron-excited states in the organism, this time in liquid media. Development of notions presented in this chapter will allow substantiating biophysical mechanisms of energy generation and transportation in biological systems.

Entropy of life

In a thermodynamic perspective, open biological systems exist in a state of unstable dynamic equilibrium [Bauer, 1935]. Such systems pass through a series of delicately unbalanced states in the process of functioning, with each state change effected in turn by changes of thermodynamic variables. Maintenance of unbalanced states in open systems is possible only at the expense of creating flows of matter and energy, both within the biological systems and between the system and its environment. From the perspective of these flows, parameters of such systems should be considered as time functions.

The entropy of an open system (dS) will vary with the interchanges with the environment (d_eS) and with entropy increasing in the system itself (d_iS), as a result of inner irreversible processes ($d_iS > 0$).

Erwin Shroedinger introduced the notion that the general change of entropy of an open system is made up of these two parts -- entropy exchange with the environment and internal entropy:

$$dS = d_eS + d_iS.$$

Differentiating this expression with respect to time, we obtain:

$$dS/dt = d_eS/dt + d_iS/dt.$$

This formulation means that the speed of change of the system entropy dS/dt is equal to the speed of exchange of entropy between the system and the environment plus the speed of entropy production inside the system.

The term d_eS/dt , considering the processes of energy exchange with the environment, can be either positive or negative, so having $d_iS > 0$, the general entropy of the system can both increase and decrease.

A negative value for the environmental exchange term, $d_eS/dt < 0$, corresponds to a condition where the outflow of positive entropy from the system into the environment exceeds the inflow of positive entropy from outside, so the overall balance of entropy exchange between the system and the environment is negative. If the environmental exchange rate is sufficiently negative to overcome internal entropy increases, then we can represent this relation with these differential expressions:

$$dS/dt < 0 \quad \text{if} \quad d_eS/dt < 0 \ \text{ and } \ \left| d_eS/dt \right| > d_iS/dt.$$

Thus, the entropy of an open system decreases at the expense of the fact that associated processes produce positive entropy in other parts of the environment.

For earth's organisms the general energy exchange can be represented simplistically as the formation of complex carbohydrate molecules from CO_2 and H_2O in photosynthesis, followed by degradation of these photosynthesis products in the processes of respiration. This very energy exchange provides the existence and development of both separate organisms – components in energy

circulation, and life on the Earth as a whole. From this viewpoint, the decrease of entropy in living systems through the processes of their vital activity is ultimately derived from the absorption of light quanta by photosynthesizing organisms. This entropy decrease is, however, excessively compensated by the formation of positive entropy within the depths of the Sun. This principle also pertains to separate organisms, for which the inflow of nutrients from the outside, carrying the inflow of "negative" entropy is always connected with the production of positive entropy where the nutrients are formed in other parts of the environment, so the sum of entropy change in the system (organism + environment) is always positive.

Having constant environmental conditions for a partly balanced open system in a stationary state close to thermodynamic balance, the speed of entropy growth at the expense of inner irreversible processes reaches some nonzero constant minimal positive value.

$$d_iS/dt => A_{min} > 0$$

This principle of a minimum of entropy growth, or Prigogine's theorem, represents a quantitative criterion for evaluation of the general direction in spontaneous changes for an open system close to equilibrium.

This condition can be represented in another way:

$$d/dt\ (d_iS/dt) < 0$$

The above inequality indicates stability of the stationary state. Indeed, if the system is in a stationary state it can't spontaneously go out of that state. Inner irreversible changes maintain the stability of the stationary state. When the system deviates from its stationary state, inner processes will take place in it and bring it back to the stationary state, which corresponds to the principle of Le-Shatelie – stability of equilibrium states. Any deviation from the stationary state will cause an increase in the speed of entropy production.

The decrease of entropy in living systems is provided by free energy, released when nutrients consumed from the outside dissociate, i.e. at the expense of sun energy. Thus, the flow of negative entropy is important to compensate for inner destructive processes and the decrease of available free energy dissipated by spontaneous metabolic reactions. This is the key issue, circulation and transformation of free energy, which drives the functions of living systems.

Diagnostic technologies based on the achievements of quantum biophysics

Based on the ideas presented above, a whole series of approaches has been developed, enabling us to investigate the activity of living biological systems. The first type of approaches are spectral methods. Of special interest in this category is the technique for simultaneous measurement of self fluorescence of NADP and oxidized flavoproteins (FP), developed by a group of authors under the direction of V.O. Samoylov. This technique is based on an application of the original optical scheme, developed by E.M. Brumberg, providing measurments of the fluorescence of NADP on the wave-length λ = 460 nm (blue light) and the fluorescence of FP on the wave-length λ = 520-530 nm (yellow-green light) at a single stage under ultraviolet excitation (λ = 365 nm). In this donor-acceptor pair the donor of π-electrons fluoresces in the recovery form (NADP), and the acceptor – in the oxidized form (FP). Naturally, the recovery forms dominate in the resting state and the oxidized forms dominate with the increase of oxidizing processes.

The technique was brought to a practical level of convenient endoscopic devices, which enable early diagnosis of malignant diseases in the gastrointestinal tract, lymph nodes during the process of surgical operations, and in skin. Estimation of the degree of tissue vital activity during surgical operations turned out to be principally important for assessing optional surgery resection. Beyond static indices, real-time fluometry reveals dynamic characteristics of biological systems, as it allows performing functional tests and investigating "dose-effect" dependence. These methods pro-

vide reliable and robust functional diagnostics in a clinic and serves as an instrument for the experimental investigation of intimate mechanisms in the pathogenesis of diseases.

Gas Discharge Visualization (GDV) technique should be understood as a development in quantum biophysics. Emission of electrons and photons from the skin surface is stimulated by short impulses (10 microseconds) of an electromagnetic field (EMF). As demonstrated by measurements using impulse memory oscilloscopy, a series of current impulses (and subsequent fluorescence) is developed, each about 10 nsec long, in the process of an EMF impulse excitation (FIG.4). Impulse development is induced by ionization of molecules in the gaseous medium, yielding emitted electrons and photons. Impulse fading results from charge buildup on the dielectric surface and initiation of an EMF gradient, directed in opposition to the initial field [Korotkov, 2002]. When a series of stimulating EMF dirge pulses with an underlying recurrence rate of 1000 Hz is being applied, emission processes are developed within the time of action of each impulse. Television capture of the time dynamics of this glow from the skin, with a scale of some millimeters in diameter, and frame-by-frame comparison of these pictures of fluorescence during each voltage impulse show that the emission centers appear approximately from the same skin points.

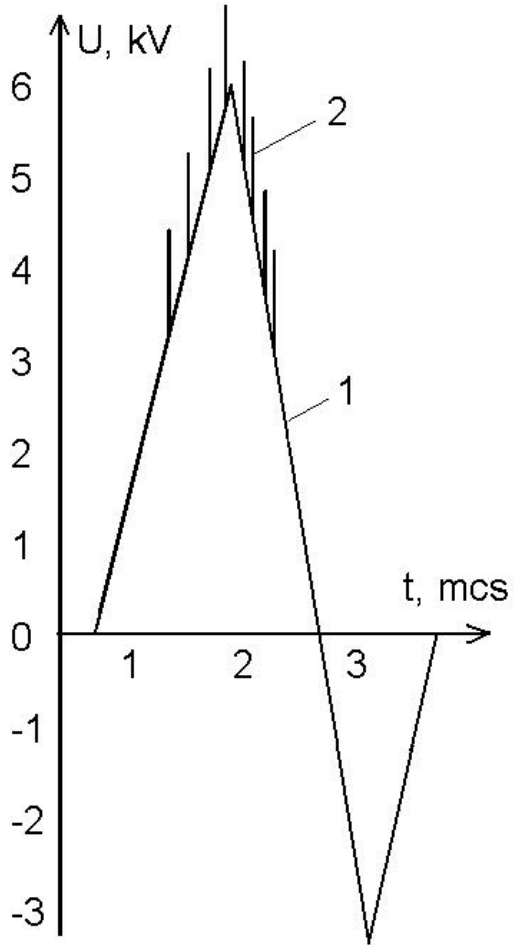

FIG.4. Schematized oscillogram of GDV impulse. 1 – dirge pulse; 2 – stimulated impulses.

Ion-depolarization processes in the tissue have no time to develop within the short period of 10 nsec, therefore the current may be resulting from the transport of electrons within structural complexes of skin or other biological tissue under investigation, included in the chain of impulse electrical current flow. Biological tissues are assumed to be divided into dielectrics and conductors (primarily biological conducting liquids). In order to unite the effects of stimulated electron emission, it is necessary to consider electron transport mechanisms along non-conducting structures. Ideas for applying models of semi-conduction to biological tissues have been proposed several times. The semi-conduction model of electron migration over long intermolecular distances within the conduction zone in a crystal lattice is well-known and actively applied in physics and engineering. Semi-conduction concepts have not yet been proven for biological systems [Rubin, 1999]. At the present moment most attention in this sphere is focused on concepts of electron tunnel transport between separate protein molecules-carriers, separated from one another by energy barriers.

The processes of electron tunnel transport are experimentally well studied and modeled by the example of transferring electrons along the protein chain. The tunnel mechanism provides the initial act of electron transfer between donor-acceptor groups in the protein, each being within 0.5 – 1.0 nm distance from one another. There are also many examples, however, where the electron is transferred within the protein for much longer distances. It is thus essential that the transfer can take place not only within the limits of one protein molecule, but may also involve the interaction of different protein structures. For example, the distance between the interacting proteins in the electron transfer reaction between cytochrome c and cytochrome b_5 is not more than 2.5 nm [Rubin, 1999].

The characteristic time of electron transfer ranges between 10^{-11} and 10^{-6} sec, which corresponds to the development time for a single emission act in the GDV technique.

The conductivity of proteins can have extrinsic character. According to experimental data, the values for mobility u [m^2/(V cm)] in a variable electrical field are ~ $1*10^{-4}$ for cytochrome and ~ $2*10^{-4}$ for hemoglobin. For the majority of proteins the conductivity is performed as a result of electron jumps between localized donors and acceptor states, separated by distances in tens of nanometers. The limiting stage in the transfer process is not movement of charge through current states, but is relaxation processes within the donor and the acceptor.

In recent years real configurations of these types of "electron paths" in particular proteins have been successfully calculated. The protein medium between the donor and the acceptor in these models is divided into separate blocks, connected by covalent and hydrogen bonds, as well as nonvalent interactions at the distance of Van der Waals radii. The electron path is thus represented by a combination of those atomic electronic orbitals, which greatly contribute to the matrix element values of component wave function interactions.

It is also generally acknowledged that particular ways of electron transfer do not have a strictly fixed character. They depend on the conformational state of the protein globule and can respectively change under different conditions. Marcus [1992] developed an approach for considering a set of electron transfer trajectories in protein, rather than a single optimal trajectory. To calculate the constant of electron transfer, orbitals which make the greatest contribution to the superexchange interaction between the donor's and the acceptor's groups were taken into account, among the entire population of electronically associated atoms in amino acid constituents of proteins. More precise linear dependencies are obtained for particular proteins using this method than when one single trajectory is considered.

The transformation of electron energy in biostructures is connected not only with transfer of electrons, but also with the migration of electronic excitation energy, which does not include electron detachment from a donor's molecule. According to modern notions inductive-resonance, exchange-resonance, and excitonic mechanisms for transfer of electronic excitation turn out to be the most important for biological systems. These processes are significant when we consider energy transfers in molecular complexes which aren't, as a rule, followed by a transfer of charge.

Conclusion

Electron-excited states in complex molecular systems are the main reservoir of free energy in biological processes. These excited states are continuously supported at the expense of electron circulation in the biosphere. The main "working substance" is water and the energy source is the sun. A part of these electron excited states is expended for the support of current energy resources in the organism. A part can also be reserved for the future, as it happens in lasers after the absorption of the pump pulse.

The flow of impulse electrical current in non-conducting biological tissues might be provided by intermolecular transfer of excited electrons, using the mechanism of quantum tunnel effects, with the activated jump of electrons between macromolecules in the contact area. Thus, it can be assumed that the formation of specific structural-protein complexes within the mass of epidermis and dermis of the skin provides channels of heightened electron conductivity, which are experimentally measured as electrical conductance at acupuncture points on the surface of epidermis. Such channels can be theoretically present within the mass of connective tissue, which can be associated with "energy" meridians. ***In other words, the notion of "energy" transfer, characteristic of the ideas of Eastern medicine and alien to most people with a European education, might be associated with the transport of electron-excited states through molecular protein complexes***. When physical or mental work is done in certain systems of the organism, electrons distributed in protein structures are transported within their given place and provide the process of oxidative phosphorylation, i.e. the energy supply for functioning of a local system. Thus, the organism forms an electron "energy depot," supporting the current functioning and being the basis for work, at some moments requiring

great resources or rapid flowing under conditions of extra-high loads -- typical, for example, of professional sport.

Stimulated impulse emission is also developed mainly by the transport of delocalized π-electrons, realized in electrically non-conducting tissue by way of the quantum electron tunnel mechanism. This proposition allows an assumption that the GDV technique provides indirect judgment about the level of energy resources at the molecular level of functioning in structural-protein complexes.

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