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

KONSTANTIN KOROTKOV, Ph.D.,[1] BERNEY WILLIAMS, Ph.D.,[2]
and LEONARD A. WISNESKI, M.D., F.A.C.P.[3]

ABSTRACT

Objective: To explain the energetic physiologic basis for acupuncture electroconductance effects and for gas discharge visualization (GDV) assessment methods, using a quantum biophysical model of entropy and information flows.

Description: The main reservoir of free energy in biologic processes is electron-excited states of complex molecular systems. Communities of delocalized excited ?-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 ?-electrons. Stimulated by high voltage impulses, optical emissions, with amplification in gaseous discharge, are registered by optical sensors (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 physiologic parameters. For example, post-surgery recovery progress is correlated with GDV parameters and GDV assessments provide independent diagnostic measures of psychophysical reserves in athletes.

Conclusion: GDV 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.

'St. Petersburg Technical University 1TMO. Russia.
[2]Holos University Graduate Seminary. Fairview, MO.
[3]George Washington University Medical Center.

INTRODUCTION

A precise definition of what we understand as "energy" in relation to biologic 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 bio physical quantum concepts can, however, provide a conceptual understanding of the energy transfer mechanisms in biologic 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 milliseconds (ms) 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; GDV). Before discussing the assessment processes, let us first explore the electron mechanisms in biophysical processes in some detail.

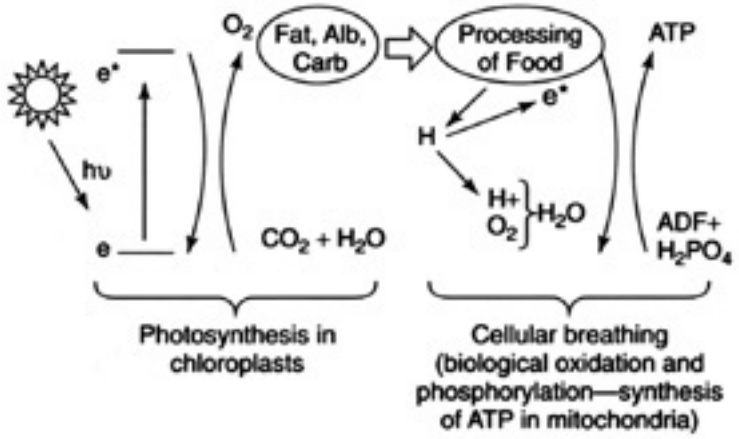

FIG. 1. Electron scheme of life (Samoylov, 2001).
ATP, adenosine triphosphatase. Carb, carbohydrates, Alb, albumin.

ELECTRON SCHEME OF LIFE

"I'm deeply sure that we will never he able to understand the essence of life, if we restrict ourselves to the molecular level. . . Ë *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-Gyorgyi. 1968

The circulation and transformation of energy in biologic 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. 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.

After the loss of its electron, the chlorophyll has a free electron vacancy. 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 (Rubin. 1999: Samoylov. 2001) 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 multistep 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 as a result of the energy contained in the electrons belonging to nicotinamide adenine dinucleotide phosphate (NADPH) and adenosine triphosphate (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.

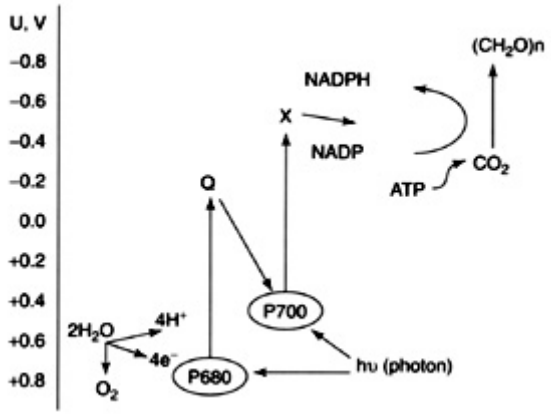

FIG. 2. Intermolecular transfer of electrons in the membranes of chloroplasts under photosynthesis. U, standard reconstruction potentials in volts; P680 and P700, chlorophyll, maximally absorbing light with wavelengths of 680 nm and 700 nm: X, ferredoxin albumen. NADPH, reduced form of nicotinamide adenine dinu-cleotide phosphate: NADP, nicotinamide adenine dinucleotide phosphate: ATP, adenosine triphosphatase.

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 (Ernster, 1992).

Being in the cell, biomolecules "live" by exchanging energy and electrical charges and. hence, information, provided by a developed system of delocalized ?-electrons. *?*-electrons contribute to the organization of any organic molecule. Each carbon atom in the linear chain contributes one ?-electron to the energy level scheme. For example, in case of 1, 3-butadiene there are four *?* electrons spread over approximately four C-C bond lengths. The average C-C bond length is approximately 1.4 A. In azulene the 10 *?*-electrons are delocalized around the periphery. So the individual electrons of the particular atoms lose their individuality and form an electron cloud in the organic molecule. At the same time these are electrons that form molecular bonding because of the overlapping of parallel electron clouds of two molecules.

Delocalization means that the collection of ?-electrons is distributed in a certain way over the entire structure of a molecular complex. This enables the ?-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 (Weiss, 1942), and the quantum-mechanical model of this process was developed by a Nobel Prize winner R.S. Mulliken, Ph.D., in 1952-1964 (Mulliken, 1975).

The most important mission of ?-electrons in biologic processes derives not only from their delocalization, but also from the peculiarities of their energy status. The difference between the energies of the main and the excited state is much smaller for ?-electrons than for ?-electrons (local electrons) and is approximately equal to the photon energy h?.

Because this small difference between the ground state and the excited state is equal to the photon energy, these delocalized ?-electrons can accumulate sun energy. Thus the entire energy supply of biologic systems is provided by them. Therefore, ?-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 *?*-electrons under photosynthesis is mainly provided to cellular "breathing" (ATP synthesis). Thus, at the expense of absorbing two photons in the chloroplast, ?-electrons are transferred from P680 to ferredoxin (Fig. 2), increasing their energy in approximately 241 kJ/mol. A small part of this energy is spent during the transfer of ?-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 ?-electrons provides 220 kJ/mol. Therefore, prior energy decrease for the ?-electrons has been only 20 kJ/mol. More than 90% of sun energy reserved by ?-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 w-links and cannot 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 —12.56eV. All molecules of the biosphere have ionizing potentials lower than this value. The range of values is approximately within 1 eV (from 11.3-12.56 eV).

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.

Dimension BP (biopotential) in Figure 3 is the dimension of free energy of the corresponding substances (in kJoules). The scale on the left (represented in electron volts [eV]) shows the difference in ionization potential for each substance, between the redox-pair of that molecule and the standard redox-pair $O_2/Í_2Î$. 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} J. (The Faraday constant represents the amount of electric charge carried by 1 mol 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 biologic tissues, which may be associated with meridian flow.

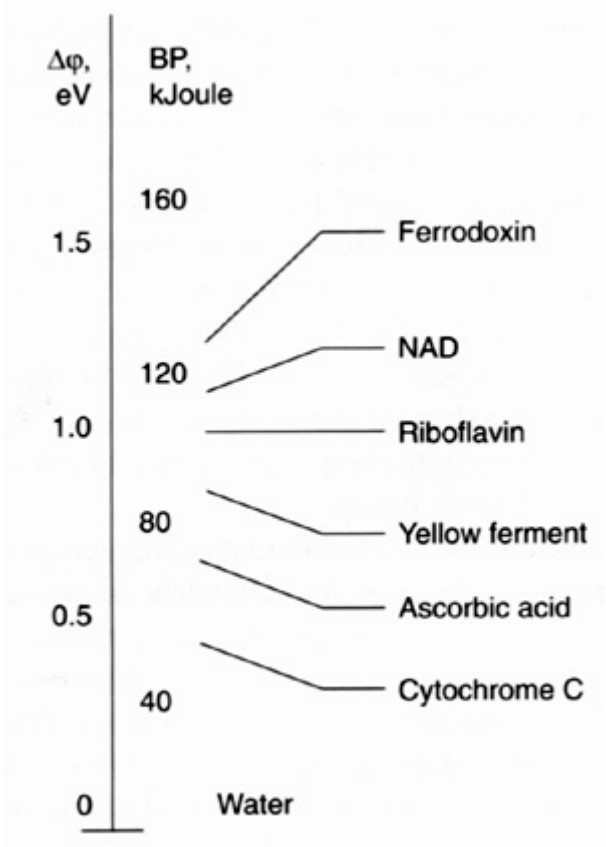

FIG.3. Scales of ionizing potentials and biopotentials (according to Szent-Gyorgyi. 1968). NAD, nicotinamide adenosine dinucleotide.

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. Racker, some carriers are concentrated on the outer side of

interior mitochondrial membranes, other carriers are concentrated on the inner side, a third group (cytochrome ñ 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 ?-electrons into the free energy of the end phosphate link ATP.

From the discussion presented above we may conclude that the main reservoir of free energy in biologic 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 ?-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.

Biologic tissues are assumed to be divided into dielectrics and conductors (primarily biologic conducting liquids). In order to unite the effects of stimulated electron emission, it is necessary to consider electron transport mechanisms along nonconducting structures. Ideas for applying models of semiconduction to biologic tissues have been proposed several times. The semiconduction 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. Semiconduction concepts have not yet been proven for biologic systems (Rubin, 1999). At present, 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.

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 ?-electrons, realized in electrically nonconducting tissue by quantum electron tunnel mechanisms.

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 ñ 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} seconds, 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 ? [m^2/(V cm)] in a variable electrical field are approximately 1 X 10^{-4} for cytochrome and approximately 2 X 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 that make the greatest contribution to the super-exchange 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 recent concepts of electron processes in biologic systems, the most important are inductive-resonance, exchange-resonance, and excitonic mechanisms for transfer of electron excitation. These

processes are significant when we consider energy transfers in molecular complexes, which are not. as a rule, followed by a transfer of charge.

ENTROPY OF LIFE

In a thermodynamic perspective, open biologic 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 biologic 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 Shrodinger 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 change:

$$dS = d_eS + d_iS$$

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:

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

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 $H_2\hat{I}$ 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 plus environment) is always positive. Having constant environmental conditions for a partly balanced open system in a stationary state close to thermo-dynamic 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 cannot 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 Le Chatelier principle—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 biologic systems. The first types 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 measurements of the fluorescence of NADP on the wavelength ? = 460 nm (blue light) and the fluorescence of FP on the wavelength ? = 520-530 nm (yellow-green light) at a single stage under ultraviolet excitation (? = 365 nm). In this donor-acceptor pair the donor of ?-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 biologic systems, as it allows performing functional tests and investigating dose-effect dependence. These methods provide reliable and robust functional diagnostics in a clinic and serve as an instrument for the experimental investigation of intimate mechanisms in the pathogenesis of diseases.

Another method that should be understood as a development in quantum biophysics is the GDV technique. It finds interesting applications for studies of both human psy-chophysiologic state (Bundzen et al., 2002a. 2002b) and of ultradiluted liquids (Bell et al., 2003: Korotkov. 2002). A lot of data are presented in the latest collection of papers (Korotkov, 2004). Most people in the United States know little about the fundamental processes of bioelectrography visualization (and their limitations) so a description is needed.

The scheme of the GDV process is shown in Figure 4. A transparent conductive layer is evaporated on the bottom surface of the glass plate 2. For durations ranging from 0.1-10 seconds, a train of square wave 3-5 ms electrical impulses of 3-6 kV amplitude (with a steep rise of $I0^6$ V/s and a repetition frequency of 10^3Hz). are applied to this layer—generating an electromagnetic field (EMF) around the subject 1 (finger or drop of liquid). Under the influence of this field, the subject produces a burst of electron emission and optical radiation light quanta in the visual and ultraviolet range at 4. These particles and photons initiate electron-ion avalanches, giving rise to a sliding gas discharge 3 along the dielectric surface (Boyers and Tiller, 1973). Spatial dis-tribution of the discharge channels is registered through the glass plate by the optical system at 6 with a charge-coupled device television camera 7 and digitized in the computer 9 using a videoblaster 8. This method is called the biological emission and optical radiation GDV technique and images after processing are called GDV-grams (Korotkov, 2002).

Two important material parameters govern the amount of light generated. They are (1) the primary Townsend ioniza-tion coefficient (which depends on gas composition, electric field, electron emission from a subject, and gas pressure) and (2) the secondary Townsend ionization coefficient (which depends on the electron multiplication processes that occur at the subject/gas interface and at the dielectric/gas interface). For the nonconductive subject, the following occur; secondary electron emission events via gas ion collisions with the surface, electron tunneling and exoelectron emission from subsurface trapping states, and covalent band states.

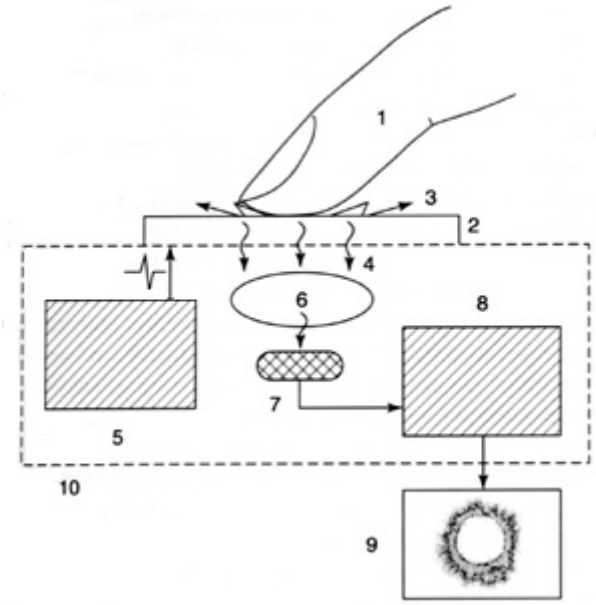

FIG. 4. The experimental scheme of the gas discharge visualization technique: 1. subject under study; 2. optical glass with coating underneath: 3, gaseous discharge: 4. optical radiation; 5, impulse generator; 6. optical system; 7. charge coupled device camera; 8. video digitizer; 9. personal computer: 10. device box. NADP, nicotinamide adenine dinucleotide phosphate.

For the human finger, mucopolysacharides are analogous to covalent band states and their various side groups could be considered analogous to the trapped states. In addition, some amount of sputtering may occur at the skin surface (stratum corneum) introducing some molecular fragments into the local gas phase and thus alter the primary Townsend ionization coefficient. Geometrical heterogeneities in the trap states around the surface of the test subject can generate patchy values of the secondary ionization coefficient so that the light emission pattern may have blank spots in it. In addition, the refilling of these trap states by electron and ion conduction from within the test subject is a critical replenishment needed for sustained exoelectron emission (these processes relate to the memory margin effect) (Tiller, 1987).

The processes giving rise to the electron emission are: (1) incident photons (mainly ultra-violet) from the ion-electron recombinations events in the air: (2) exoelectron emission and electron tunneling from a subject due to the applied voltage: and (3) collision energy exchange (Boyers and Tiller, 1973: Korotkov, 2002).

As demonstrated by measurements using an impulse memory oscilloscopy, a series of current impulses (and subsequent fluorescence) is developed, each about 10 nanoseconds long (10^{-8} seconds), in the process of an EMF impulse excitation (Fig. 5). Impulse development is induced by ion ization 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. Ion-depolarization processes in the tissue have no time to develop within the short period of 10 nanoseconds, therefore the current may be resulting from the transport of electrons within structural complexes of skin or other biologic tissue under investigation, included in the chain of impulse electrical current flow. It is this last aspect in the human finger/body system that links the GDV system to the acupuncture point and acupuncture meridian system. Two known processes inside the skin respond to time-varying voltages applied to the surface of the skin. One is space charge transfer across the basal membrane of the skin with a time constant of microseconds. The other is an ion conduction process between the cells of the stratum corneum with a time constant of seconds. Only the current flow of the rapid process can replenish the trapping charge states needed for exoelectron emission in the GDV process, and it is the acupuncture meridian that is the primary channel for such current flow.

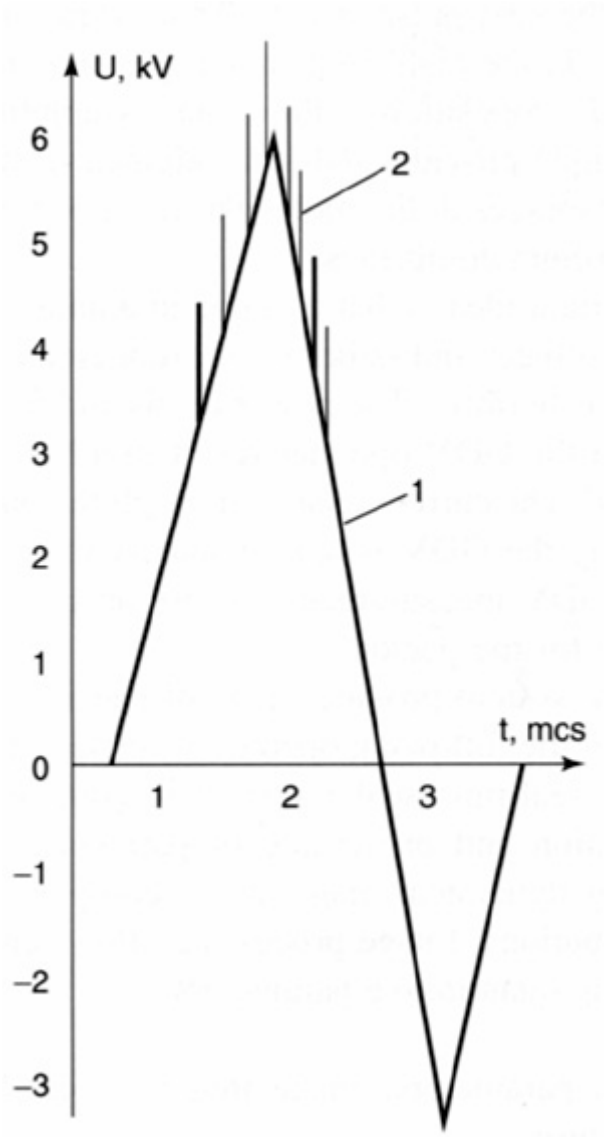

FIG. 5. Schematized oscillogram of gas discharge visualization impulse: 1. dirge pulse; 2. stimulated impulses. U, standard reconstruction potentials in volts.

By definition, a dielectric acts to enhance the capacitance of a material. In our case the human finger acts as a dielectric. The GDV also has a dielectric with a transparent electrode behind it. In human tissue, the dielectric response is a function of the electric permeability of the skin and the frequency applied to the voltage used when making a measurement. The dielectric properties of the skin decrease with increasing frequency because of the time required for charges to form and migrate across the interfaces and interact with the opposing electrode.

At low frequencies on the order of 10-100 seconds, a conduction current exists, allowing charge to be transferred across the stratum corneum. When the applied voltage is alternating current (AC) at approximately 1000 Hz. the impedance (resistance) slowly increases with time, but to a smaller degree than when direct voltage is applied over a period of time. This effect is attributed to the selective permeability nature of the cell membranes (they pass positive ions more easily than negative ions) and the short-circuit channels between the cells. At approximately 10^3 Hz repetition rate, with a positive going square wave voltage pulse of *3-5* ms applied (as is the case for the GDV); there is time for the charge to rise to a point of breakdown. Then, with the approximately 1 ms that exists between the voltage pulses, there is almost sufficient time for the charges to decay before the next pulse arrives. Thus, variations of finger conductance in the high frequency region are detectable.

Presented propositions 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.

An important idea is that it is not an applied voltage that can harm a subject, but rather the current created within the subject that is harmful. The power levels and frequency levels at which the GDV operates result in a low current that is short lived. The current created through the body's meridians by using the GDV is approximately 0.1-10 /?À. This makes the GDV measurement process absolutely safe and noninvasive for the person.

The GDV system provides a set of specialized software programs for the following operations: observation of GDV images in a real-time scale; storage in computer memory; image filtration and processing of parameter calculations and creating dynamical diagrams of complex GDV parameter distributions. Image processing allows calculation of the following quantitative parameters:

- Geometric parameters: image area, number of fragments, level of noise:
- Spectral distribution:
- Fractality parameters: form coefficient and fractality ac cording to Mandelbrot;
- Entropy probability measures in accordance with the ideas presented above and numerical principles developed in (Korotkov and Korotkin, 2001):
- Statistical parameters.

Several years of GDV research have provided clinical correlations that position GDV measures together with well-accepted physiologic parameters. Postsurgery recovery progress is correlated with GDV parameters. Research on a large contingent of top athletes demonstrates complimentary dependence of GDV parameters: both on actual psychophysic 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 psychomo-tor potential. Interested readers can find surveys of research in the references to this article. So we can conclude that GDV quantum parameters may serve as an important measure in the evaluation of health and well-being, both in coordination with well-accepted measures and on their own.

CONCLUSION

Electron-excited states in complex molecular systems are the main reservoir of free energy in biologic 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 nonconducting biologic 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 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 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 ?-electrons, realized in electrically nonconducting 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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Address reprint requests to:
Berney Williams, Ph.D.
1310 George Court #1Lawrence. KS 66044

E-mail: berneyw@wa/7.ku.edu