THE CERTAINTY PRINCIPLE AND PHYSICAL NATURE OF PHOTOSYNTHESIS MECHANISMS INITIATION AND BIOENERGY SYSTEMS FUNCTIONING

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The article represents additional experimental results of certainty principle discovery on the examples of double-stranded DNA (RNA) replication and the translation of genetic data of DNA → RNA → Protein, the genealogy of homogeneous and isotropic geometric structures formation both in thylakoid membrane during photosynthesis and in chloroplasts, mitochondria and photosynthetic bacteria.

It was shown that physical nature of photosynthesis initiation and energy-synthesizing systems functioning is the light quantum (γ) breakdown into an electron and a positronium-ion in accordance with C-violation effect. Besides, out of eight 8γ only six disintegrate into three electron-positron pairs of $6\gamma = 0.826\,e^- + 2.174e^+$, and 2γ disintegrate into electrons only.

Quantitative calculations based on the general certainty equation of energy-synthesizing systems functioning

$$8\gamma = \Delta p = \Delta\psi + \frac{RT}{F}\left[\left(0.826e^- + 2.174e^+\right) + e\ \right]$$ allow disclosing inner mechanisms of electrochemical gradient emergence, and the membrane potential during the transfer of one electron from $(2\gamma = 1e)$ through the membrane with the energy equal to 21.4 kJ/mole (or $\Delta\psi = 0.222V$).

In works [1, 2] we have presented the evidence of development of many spontaneous processes (physical, chemical, biological, mixed, etc.) according to the certainty law (by Lokhov). For example, during photosynthesis the photosystem PII absorbs the red quantum of sunlight (γ) at 680 - 683 nm with the energy not exceeding 1.84 eV. With the release of this photon from the excited photosystem P*680 to phaeophytin at a speeds of 10^{-15}-10^{-19} sec, there occurs disintegration of γ_{II} into an electron-positron pair in accordance with C-violation effect (1)

$$8\gamma_{II} = 0.826e^- + 2.174e^+ \leq 150eV .\qquad(1)$$

During disintegration of $8\gamma_{II}$ the particles exceeding the electron mass not four times, but three times are formed.

Based on the certainty equation (2) the quantum of time $\Delta t^{"}$ is calculated

$$\Delta E \cdot \Delta t = \Delta E^1 / \Delta t^{"}\qquad(2)$$

within the limits of which the ratio between the energy release ΔE and the carry time (Δt), through the chain of A_5-components in photosynthetic space (centre) at a speeds of K<10^{-10} s, remains constant (3)

$$\Delta\mathrm{E} \cdot \Delta t = const .\qquad(3)$$

Theoretical calculations of the certainty equation (1) for the launch of mechanisms of the first and second stages of photosynthesis, as well as the new universal mechanism of the genome activation of all living bodies [3] find full experimental confirmation [1, 3 -5].

The modern quantum mechanics was created on the basis of Heisenberg's uncertainty principles. In this connection, there arises a by no means idle inquiry related to mutual correlation of two discussed principles.

This work is aimed to prove that the certainty principle is the new universal physical-chemical law of nature.

Formation of homogeneous and isotropic geometric structures of DNA

In work [6] the direct proof of Euclid's statement about parallel lines intersection, which was formed as early as in III century BC [7] in the form of a theorem, is provided.

On the examples of reparation (removal) of erroneous sites in double-stranded DNA or RNA chain on the stages of replication (untwining of double-stranded DNA and RNA), mitosis and recombination between sister chromatids it is shown that, in contrast to the heterogeneous and non-isotropic Lo-

bachevsky's and Riemann's geometry, or any other, in the geometry proposed by Lokhov the space-and-time becomes homogeneous and isotropic.

There can be created an infinite number of geometries, as logical systems. It is important to just determine in which of an infinite number of indeterminate geometric structures the frequency of errors, such as in

- inclusion of a wrong heterocyclic base into guanine-cytosine (G - C) and adenine-thymin (A-T) pairs in DNA chain;
- untwining of two antiparallel chains of DNA molecules in non-homological and homological sections;
- chromosome disjunction in daughter cells;
- recombination between sister chromatids, etc.,

which is described by the uncertainty principle

$$\Delta_{x\cdot} \cdot \Delta_p \approx h, \tag{4}$$

is transformed into the certainty principle in homogeneous and isotropic space-and-time (5)

$$\Delta_{x\cdot} \cdot \Delta_p = 0. \tag{5}$$

Deduction: the replication mechanism (that of DNA and RNA double-stranded chains untwining) is universal for all living bodies – from bacteria to highest eukaryotes [8-10]. In this complex enzymatic process the DNA-dependent DNA polymerase provides the replication. For example, in bacteria in a rigorously defined unique region close to the *ilv* gene positioned in 74' in a standard chromosomal map of the colon bacillus E.Coli the replication takes place simultaneously in both strictly opposite directions with the velocity of about 800 nucleotides per second. Two replication forks (the region, where a simultaneous untwining of double-chain DNA and RNA and the synthesis of nucleic acids' macromolecules on every of these chains-matrices happens) are seen nearby the

trp **25'** marker in the chromosomal map (Fig. 1).

The genetic analysis suggests [8-11] that the nucleotides coming out of the replication fork very often undergo spontaneous point mutations. It has been found that the errors of a wrong heterocyclic basis insertion in the pair guanine-cytosine (G-C) and adenine-thymine (A-T) in the DNA chain, from a rigorous sequence, which is a concrete genetic information been defined by, often happen at the stages of replication (l per 100 000 base pairs), mitosis (l per 1000) and, most often, - in the course of genetic recombination between sister chromatides.

The evolution has developed a universal mechanism for the removal (reparation) of wrong points and formation of rigorously equal sequence and length nucleotides in the

cells of living bodies [8-10, 13]. Before the complete reconstruction of a damaged region(-s) the DNA polymerases are settled in the homologous region (Fig. 2). In this case the DNA replication comes to a halt as well as the chromosome disjunction to daughter cells. At the stage of mitosis every chromosome remains connected with the spindle fibers.
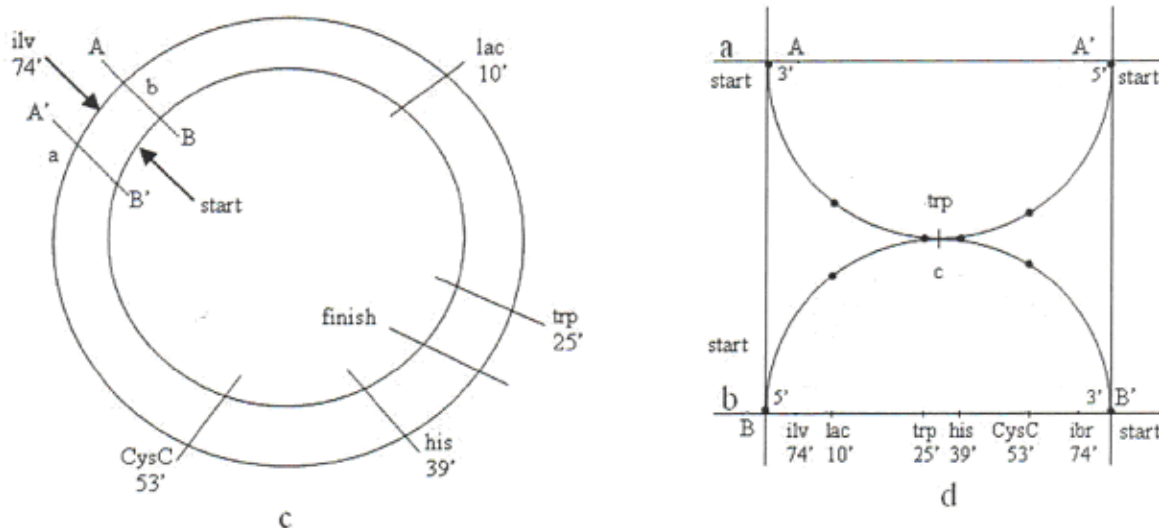

Fig. 1. The diagrammatic representation of the ring chromosome of E.Coli during the replication depending on their position in the chromosomal map. The newly formed DNA chains are synthesized in the direction 5' → 3' (- - - - ▶).
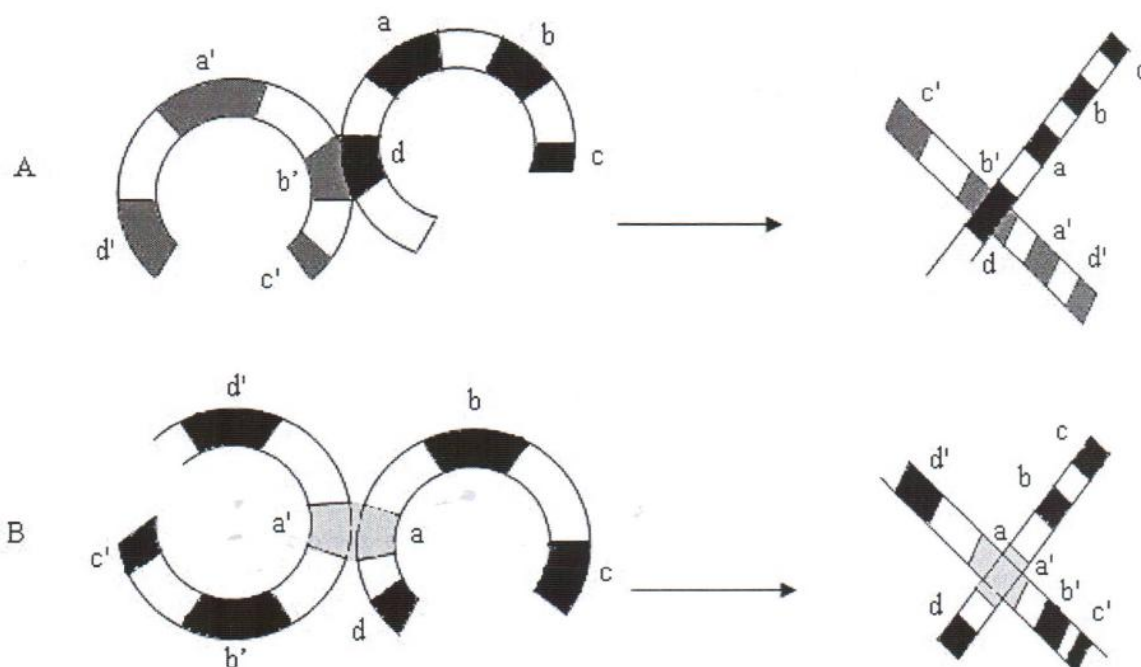
Fig. 2. The diagrammatic drawing of the untwining of two DNA molecules connected in non-homological (A) and homological (B) regions.

Let us assume that two lines AB and A'B' intersecting two parallel chains **a** and **b** of an E.Coli DNA double-stranded molecules in the region of a base pair A-T or G-C close to the ilv gene form together with them concluded angles, the sum of which is equal to the two lines (Fig. 1). Then during the replication up to the stage of mitosis the ring chromosomes of the E.Coli will be untwined into linear chains from the origin locus *ori* up to the homological region *trp(c)* (Fig.2). Under these circumstances of the cell's transition from the metaphase to telophase the parallel lines a and b will intersect each other in the point c as the mechanism of reparation guarantees both equal alteration of the concluded angles and the equal lengths of the lines **A** and **B**; **A'** and **B'** in the triangles **ABC** and **A'B'C** (Fig. 3).
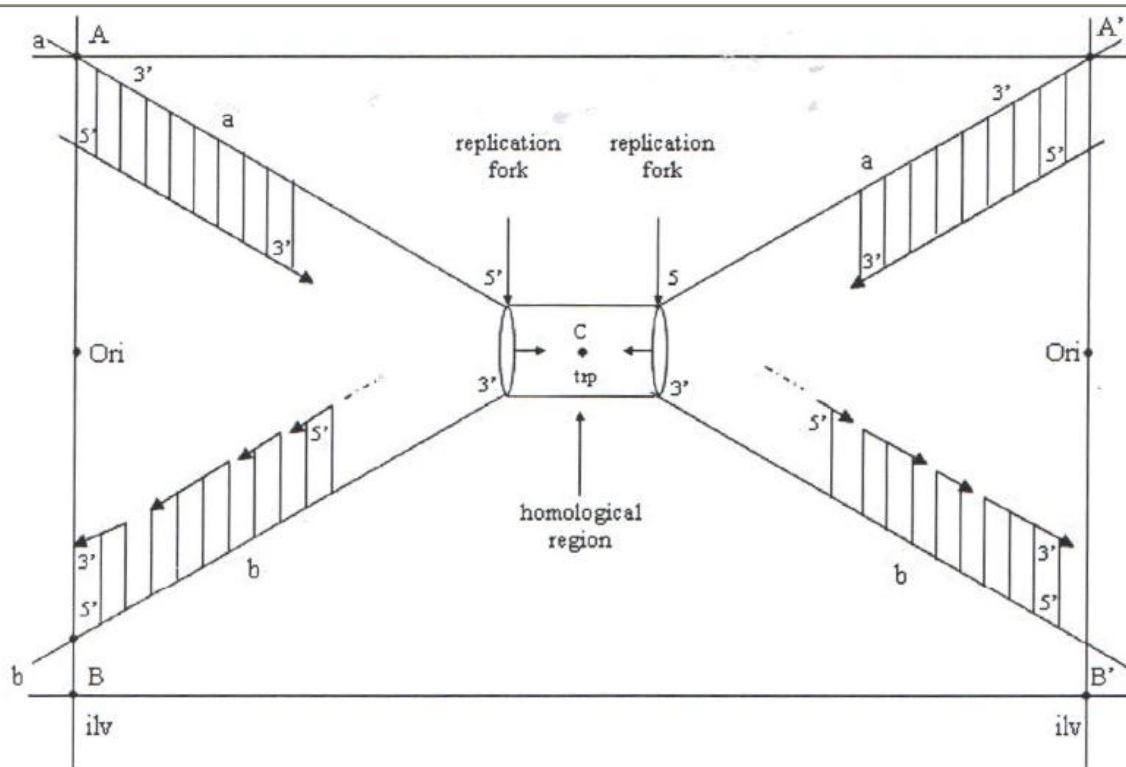
Fig. 3. The principal scheme of the intersection of two parallel disposed chains (lines) a and b of a DNA molecule of E.Coli in the homological region of the replication initiation interval and cytokinesis. From the model of two double-stranded DNA molecules J.Watson and F.Crick, one of the chains of every daughter DNA molecule is synthesized again, and the other one comes from a parent DNA molecule (semiconservative replication). The region, where a simultaneous untwining of a double-chain DNA (or RNA) and synthesis of the nucleic acids' macromolecules in every of these matrices-chains, is called a replication fork [11-12].

In some prokaryotic cells the replication fork, though moves with the velocity of about 1000 links per second, the chromosome disjunction to the daughter cells occurs with unequal speed. However, every chromosome nearby the marker *trp(c)* remains constantly connected with the spindle fibers for the period of about 30 minutes normally. This time is quite sufficient for matching of the **AC** and **BC** lengths in the triangle **ABC** (**A'C'** and **B'C** in the triangle **A'B'C** accordingly).

Although the reparation mechanism activation decreases the frequency of errors considerably in the postreplication stage up to one per 10^9 - 10^{10} counted base pairs [8-

10, 13] in the process of molecular recognition some unrepaired mutations remain always. Otherwise, the bodies of elementary and highest eukaryotes would not have expressing genes, and the evolution would unlikely be possible.

Vice versa, it is as if mutations are an integral part of homogeneous and isotropic geometric spaces formations within the interval of replication initiation (*ori*) and cell division (mitosis). So, with the increase of the DNA mass in the highest eukaryotes the number of replicons (replication units) increases (yeast - $13,5 \times 10^6$ base pairs (b.p.) drosophila - 165×10^6 b.p., human - $2,9 \times 10^9$ b.p.). In particular, in the haploid genome of mammals there are about 20 000 – 30 000 replicons, in D. melanogaster – 3500 and in S.cerevisiae yeast there are about 500 replicons. With the increase of replicons' number or, the same, triangles **ABC (A'B'C)** formed by the intersection of the parallel lines **a** and **b** (Fig.1 and 3) the number of point mutations would have to grow.

However, by the example of mitosis, we see that every chromosome, for example, in a bacterial cell, remains constantly connected with the spindle fibers for about 20-30 min and forms 4×10^9 cells in optimum conditions less than in 11 hours. Then, under the condition that a normal chromosome disjunction to daughter cells is broken not more than one time per 1000 mitoses [5-7], the number of mutations will make about 10^7. This number is comparable to about 10^7 mutant cells,

which can be formed out of 10^{13} human cells at any time.

Thus, from the abovementioned material one can conclude that the key element of the evolution of all living things on the Earth is the development of homogeneous and isotropic geometric space in one of the planes of the tree-dimensional system **dx-dy**; **dy-dz** and **dz-dx** coordinates [1] in the form of equally altered right triangle(-s) (replicon) **ABC** or **A'B'C**. Evidently, it explains that the nucleotides coming out of the replication fork have discontinuities for a time and serve as the starting point for the removal (reparation) of the erroneous regions and the development of rigorously equal sequence nucleotides. In this case any chromatid can also become a matrix for the reconstruction of another one.

Genealogy of formation of a homogeneous and isotropic geometric structure

Photophosphorylation, as well as oxidative phosphorylation, is initialized by proton driving force, and consequently, for its realization a closed space (compartment) is required. For example, light stage of photosynthesis of O_2 molecule in a spherical space of quantum system is associated with C_3 of plants with the formation of 3ATP and $2NADPH_2$ [13, 14].

In this case, the functional unit of the light stage of photosynthesis is the square of the time interval $(dL)^2$ (6) in which limits the certainty equation is realized (1)

$$(dL)^2 = \lim_{K \to i} f_k(\Delta t) \le \Delta t_i^1 , \qquad (6)$$

where Δt is the average time between the excited forms of photosystems PII and PI and is equal to 20×10^{-9}s; $\Delta t'$ is the average time of photon emission by almost all excited elements (atoms) and is equal to 1.6×10^{-6}s. For $\Delta t = 20$ns the probability of photons emission belonging to the same excited element is very high. Index i = 1 and k = 80.

Formulas (1) and (6) allow concluding that in the course of structuring of the spheri-

cal geometric space in thylakoid membrane of the quantum system, complex molecular processes of photosynthesis are being formed in parallel as well.

Indeed, let us assume that from the source of photons, placed in points ($\mathbf{x^1}$, $\mathbf{x^2}$) and $\mathbf{a'}$ of the direct line **NK** centre (Fig.4) crossing two parallel direct lines **A** and **B**, 680 and 700 nm photons are emitted respectively in the direction to the point ($\mathbf{x^1 + dx^1}$,

x^2+dx^2). The photons from the sources (x^1, x^2 and a') are emitted gradually with the interval of 20ns. For the period of $1 \div 80$(20ns) the wavelengths (or the frequency) of photons λ_2 from the source (x^1, x^2) and λ_1 from a' will be in the following correlation:
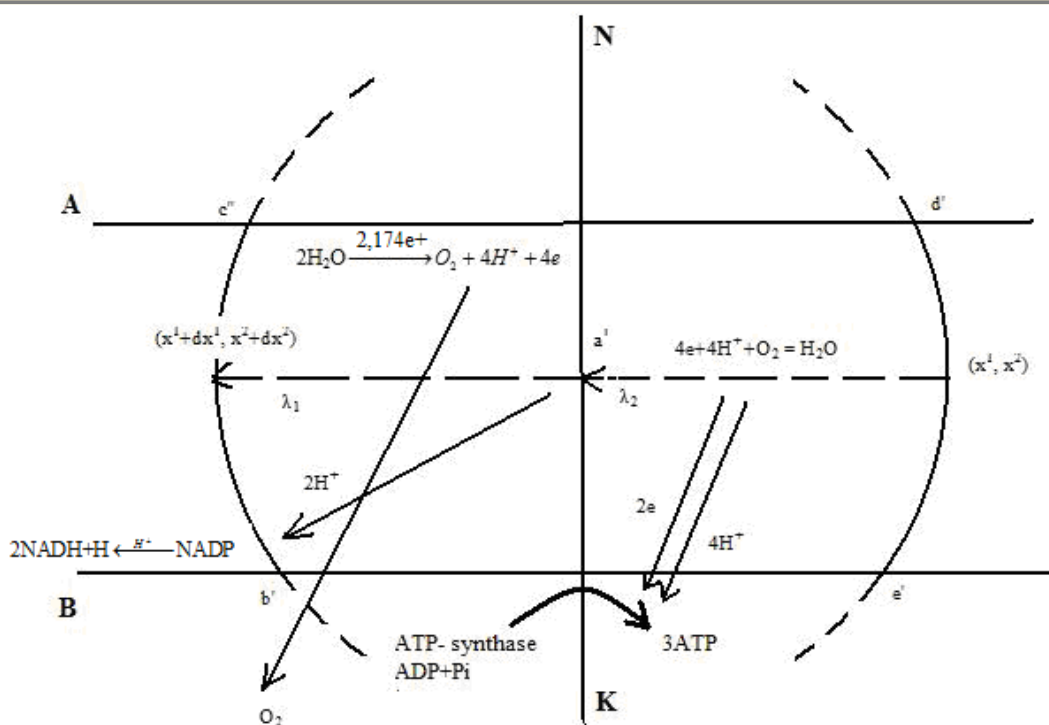
$$\lambda_1 = \lambda_2 + \frac{n\Delta\lambda}{c}, \tag{7}$$

where **n** and **c** are the average displacement speeds of photons from (x^1, x^2) and a', respectively, and $n \gg c$; $\Delta\lambda = \lambda_1 - \lambda_2$.

Then for the time of 1.6×10^{-6}s of the light-stage of photosynthesis O_2 from H_2O,

when based on equation (6) conditions $\Delta t = \Delta t^1$, the difference of angular phases of wavelengths or the oscillation frequency become coherent (8)

$$\lambda_1 = \lambda_2 + \Delta\lambda(n-c). \tag{8}$$

Fig. 4. Modeling of the genealogy of homogeneous spherical and isotropic geometry space formation and initiation of the light stage of photosynthesis occurring in thylakoids. Only homogeneousness and isotropy can explain the mechanism of "amazing" convergence in the reaction coordinate of 4e and $4H^+$ for the recovery of O_2 in one point of bioenergy chain ($4e+4H^+ +O_2=H_2O$), as well as decomposition of water during photosynthesis of $2H_2O \xrightarrow{2.174e^+} O_2 + 4H^+ + 4e(2,6,10)$

In this case, the sensor, located close to the point (x^1+dx^1, x^2+dx^2) will register the interference of waves from the sources (a' and x^1, x^2). By summation of similar indexes **i** and **k** (**i = t; k = 2,3,4,.......80**) from (6) we define the structure of the shortest distance from the point (x^1, x^2) to (x^1+dx^1, x^2+dx^2) in the form of the matrix tensor δ_{ik} in the new geometry [6]

$$(dL)^2 = \delta_{ik}(x)dx^i\,dx^k = (dx^1)^2 + (dx^2)^2, \tag{9}$$

in which, in contrast to the Lobachevsky's and Riemann's geometry, δ_{ik} is the measure of homogeneity and isotropy of the geometric space. In heterogeneous and non-isotropic environment it is impossible to draw a direct line through the above mentioned points [2, 6].

From the center a' of the distance $(dx^1)^2 + (dx^2)^2$, it is possible to describe a circle with the radius of $dl[a'; (x^1 + dx^1; x^2 + dx^2)]$, which in crossing with two parallel straight lines **A** and **B** forms a spherical homogeneous and isotropic geometric space **b' c' d' e'** with them with the equally distorted internal angles, the sum of which is less than two direct lines. The proposed by us model serves as another proof [6] of Euclid's assertion about concurrence of direct parallel lines as the theorem, which has been formed back in the III century **BC**.

A new insight in the mechanisms of energy synthesizing systems functioning

Nobel lecture by P.Mitchell delivered in 1979 was a triumph of the difficult creation of the chemosmotic theory of energy synthesizing systems functioning [15]. Currently, this discovery has gained general recognition [16].

However, this concept is extremely schematic as the physical nature itself of photo- and oxidative phosphorylation has not been determined. Consequently, the intrinsic logic of this natural phenomenon manifestation remained unclear. Below, we have pre-sented the following arguments as the evidence of the physical nature of energy synthesizing systems functioning.

1. Emergence of electrochemical and membrane potentials difference

Photosynthetic electron transfer and photophosphorylation in chloroplasts is similar to the electrons transfer and oxidative phosphorylation mitochondria [13]. According to P. Mitchell, the electrons transfer and ATP synthesis is ensured by the protonic gradient. Electron transfer along the respiratory chain leads to the emission of protons from the matrix to the cytoplasmic side of the inner mitochondrial membrane. As a result of the occurring growth in the concentration of ions H^+ there occurs the generation of the membrane potential with a positive charge on the cytoplasmic side of the membrane. This is the proton driving force that initiates the synthesis of ATP by ATP-ase complex.

In its turn, the flow of electrons through the electron-transport chain from photosystem PII to photosystem PI leads to the occurrence of a proton gradient leading to the synthesis of ATP.

Thus, we can conclude from the chemosmotic theory that the mechanism of energy synthesizing systems functioning in mitochondria, chloroplasts and bacterial cells in general is the same, and the general electrochemical potential Δp is formed of the membrane potential ($\Delta\psi$) and the gradient of ions concentration H^+(ΔpH)

$$\Delta p = \Delta\psi - \frac{RT}{F}\Delta pH = 0.224V , \qquad (10)$$

where R is a gas constant, T is the absolute temperature and F is Faraday number. In (10) $\Delta p = 0.224V$ corresponds to free energy 21.76 kJ/mole per 1 mole of protons [13, 16].

However, on the basis of (10) it is not possible to find out the reason of distribution of electric charges ($\Delta\psi$ и ΔpH) on both sides of the membrane.

At the same time, the equation of certainty (1) just allows to disclose the physical nature of emergence of both the membrane potential ($\Delta\psi$) and the gradient of ions concentration of H^+ (ΔpH).

Let us assume the charge separation as the criterion of ATP synthesis in chloroplasts, photosynthetic bacteria and mitochondria. Then, taking into account that for $\Delta t = 8(20ns)$ out of eight photons only $6\gamma_{II}$ will split into three electron-positron pairs, and $2\gamma_{II}$ – into an electron, the equation of cer-

tainty (1) can be written in general terms as follows (11)

$$8\gamma_{II} = \Delta\psi + (0.826e^- + 2.174e^+), \tag{11}$$

where the difference of charges $\Delta pH = 1,348$ units, which coincides with the experimental data [13, 16].

In the works [3, 5] we have shown that at the concentrations of ATP, ADP and Pi equal to 40, 0.93 and 8.05 mM respectively and pH values of 7.0 and the temperature of 25^0C, the true free energy of the substrate phosphorylation in cells (ΔG) is equal to

$$\Delta G = \Delta G^{01} + 2.303RT \lg \frac{[ADP][P_i]}{[ATP]} = -51.9 kJ / mole, \tag{12}$$

where ΔG^{01} is standard free energy.

In standard thermodynamic conditions out of 51.9 kJ/mole of energy 30.5 kJ/mole are required for the synthesis of one molecule of ATP from ADP and Pi [13]. Then the difference of 21.4 kJ/mole is the equivalent of the proton driving force equal to 0.224 V [13, 17], as in (10).

On the other hand, the difference of 21.4 kJ is free energy of electron transfer (charge z) through the membrane of energy

synthesizing systems. If for the transfer of one electron (charge) through the membrane with transmembrane potential $\Delta\psi=10$ mV it is required zF$\Delta\psi=0.965$ kJ/mole [17], then the energy of membrane potential in (11) is equal to $\Delta\psi = 0.222$V, which conforms well the literary data [13, 15, 16].

Summarizing the equations (10) and (11), and taking into account that 4e are formed [13] during the decay of 8γ

$$8\gamma_{II} = \Delta p = \Delta\psi + \frac{PT}{F}\left[\left(0.826e^- + 2.174e^+\right)+e\right], \tag{13}$$

where $\Delta pH = [(0.826e^- + 2.174e^+)+e]=4$, which indicates that in conditions when in the process of synthesis and decomposition of ATP the concentration of ATP will be equal to the concentration of ADP, the potential on the membrane will be $\Delta\psi = 0$. In this

case, the synthesis of ATP can be done at the expense of the difference in protons concentration on both sides of the membrane equal to $\Delta pH=4$[17]. In order to transfer $2H^+$ through the membrane the following potential is required

$$\Delta p = \frac{RT}{F}\left(\Delta pH\right) = 0.06\left(4\right) = 0.240V, \tag{14}$$

which also conforms well the literary data [13, 16].

In particular, purple photosynthetic bacterium does not produce oxygen, and instead of chlorophyll a and b in chloroplasts it contains bacteriochlorophyll. While absorbing a quantum of energy, bacteriochlorophyll transfers into the excited state and further rapidly transmits an electron through acceptor chains A_1, A_2, A_3 ......A_i at a speed of

about 10^{-11}. This electron, while moving in the secondary acceptor, initiates the cascade of events of "apochlorotic photosynthesis", for the full completion of which several seconds are required. Reduced speed of electron transfer to A_i leads to annihilation of the electron and the positron. The released energy leads to the emergence of the concentration gradient of ions H^+ on both sides of the membrane that underlies the functioning of

bacteriorhodopsin as the light dependent proton pump.

Vice-versa, in thermodynamic physiologically significant [17] equilibrium conditions (the ratio of ATP/ADP<1) the gradient of protons on both sides of the membrane is absent. For example, in chloroplasts (ΔpH = 0) the value of membrane potential reaches the value of (15)

$$\Delta p = \Delta \psi = 0.222V. \tag{15}$$

At the same time, the functioning of mitochondrial organelle is formed of the membrane potential ($\Delta\psi$) and the gradient of ions concentration H^+(ΔpH). Provided that the synthesis of ATP can be done at the expense of the difference of the protons concentration on both sides of the membrane of energy synthesizing systems, the units formed by the difference of charges of the electron and positron-ion 1.348 in (13), can be written as in (16)

$$8\gamma_{II} = \Delta p = \Delta \psi + \frac{PT}{F}\left(0.826e^- - 2.174e^+\right) = 0.222V \ , \tag{16}$$

where from $\Delta\psi$=0.1411V, which corresponds well to the chemosmotic theory of P. Mitchell [13, 15]. It was known that pH in the outer side is 1.4 units is lower than from the inner side, and the membrane potential is equal to 0.14 V.

2. Convergence of 4e and 4H+ during O2 restoration and H2O decomposition into 4e and 4H+

In literature, the mechanism of "amazing" convergence in the reaction co-ordinate of 4e and $4H^+$ for the restoration of oxygen during associated oxidative phosphorylation (17).

$$O_2 + 4e + 4H^+ \rightarrow 2H_2O \tag{17}$$

as well as during water decomposition at photosynthesis (18)

$$2H_2O \rightarrow O_2 + 4e + 4H^+ \tag{18}$$

has not been established [13, 15, 16].

A.A. Logunov in work [18] showed that in Lobachevskiy's, Riemann's geometry, or in any other, the space-and-time is not homogeneous and not isotropic. In such space-and-time, the collisional frequency of interacting particles (like the frequency of errors at simultaneous measuring of the position and the speed of particles or the energy of the system at a given time) will be described by Heisenberg's principle of uncertainty:

$$\Delta x \cdot \Delta p \approx \left(\lambda / \sin \alpha\right) \cdot \left(h / \lambda \cdot \sin \alpha\right) \approx h . \tag{19}$$

However, in the geometry proposed by R. Lohov [6], with the transition from a relatively large and, possibly distorted, three-dimensional space into the infinitely small volume of a geometric structure the space-and-time becomes homogeneous and isotropic [2, 6]. Accordingly, in such a space the principle of uncertainty is transformed into the principle of certainty (20)

$$\Delta x \cdot \Delta p \approx 0 \text{ and } E \cdot \Delta t = const , \tag{20}$$

that underlies the evolutionary development of living and plant organisms.

Equation (20) suggests that the squared distance between the neighbour points (x^1, x^2) and ($x^1 + dx^1$, $x^2 + dx^2$) shall be written in the form of a straight line, in contrast to Lobachevsky's and Riemann's geometry (Chapter III):

$$(dl)^2 = \delta_{ik}(x)dx^1\ dx^2 \tag{21}$$

where δ_{ik} is the matrix tensor, measure of homogeneity and isotropy.

Thus, the key element in the evolution of all living bodies on the Earth is the formation in vivo homogeneous and isotropic geometric space on one of the planes of three-dimensional coordinates.

Apparently, the formation of mutations in the interval of replication initiating and cell division (mitosis) in accordance with the principle of uncertainty serves as the starting point for the initiation of the mechanisms of reparation (removal) of erroneous heterogeneous and non-isotropic sections of DNA (RNA) molecules and the formation of nucleic acids strictly in accordance with the certainty principle in restructuring and functional organization.

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