



WET-AND-MURBURN-MEMBRANE-MODEL

PART II: EFFECTIVE CHARGE SEPARATION AND POTENTIALS; AETHER PROTOPLASM INTERACTION PROPOSAL

Laurent Jaeken

Department of Industrial Sciences and Technology. Karel de Grote Hogeschool. Antwerp University Association. Antwerp, Belgium

*Classic understanding of membrane potential as due to electrogenic ion pumping is untenable. In the new Wet-and-Murburn-Membrane-Model (WMMM) the sub-threshold R-state is the high-energy low-entropy excited coherent state and all processes (hyperpolarization, rest, generator potentials) are equilibrium-based. A phase transition occurs upon surpassing threshold, whereby the energy stored in the R-state is transformed into an all-or-none propagating action potential, a soliton. Only during the refractive period metabolic energy is introduced into the system by murburn redox processes directly and indirectly through adsorption of ATP produced by murburn phosphorylation. All processes are primarily due to electron displacements in redoxes and Lewis-induction. Ion currents are secondary, local, and do not propagate longitudinally along the axon. Permeability changes of the membrane upon surpassing threshold are due to changes in the structure of water. The process of changing low-energetic non-polarized water into highly excited polarized multi-layer water with a fourth phase 3D-structure depends on the combination of ATP adsorption energy and murburn redox activity. The fourth phase structure can extract energy from the quantum vacuum (aether). After Thomson and Bourassa corrected a mistake in the mainstream concept of charge, they could derive a physical description of the aether as a rotating magnetic field. Hereby aether units can house elementary particles in regions where there is matter. When electrons are highly excited and highly ordered (as in fourth phase water) energy and information from the aether field can be tapped. The Aether Protoplasm Interaction Proposal (APIP) suggests that the transformation of fourth phase water into non-polarized/de-structured water (rest-to-action transition) goes along with lowered interaction with the aether. This is what is observed in MRI. **Biomed Rev 2025; 36: 85-107***

Keywords: cell potential, ROS, murburn concept, phase transition, polarized water, thermodynamic approach, aether

Abbreviations: WMMM: wet & murburn membrane model; MPT: membrane-pump theory; AIH: association-induction hypothesis; POM: polarized oriented multi-layer; DROS: diffusible reactive oxygen species; ADRS: anions of DR(O)S radical cascade; A-state: action state; R-state: resting state; A-to-R: action to rest; R-to-A: rest-to-action; HHK: Hodgkin-Huxley-Katz model, GHK: Goldman-Hodgkin-Katz equation; ECS: effective charge separation; $\Delta\Psi$: potential difference; EZ: exclusion zone; (water)-CD: (water) coherent domain; NKA: Na/K-ATPase, APM: Aether Physics Model. APIP: Aether Protoplasm Interaction Proposal.

* Correspondence to: laurent.jaeken@hotmail.com

INTRODUCTION

The 'Wet and Murburn Membrane Model' (WMMM) (1) presents a new understanding of membrane functionalities through integration of previously non-considered data of primary importance and by re-interpreting well-known data that were incorrectly explained and led to a way of thinking of how membranes are *supposed* to exert some functions (namely by ion pumping), while they don't. In classic thinking about membranes, which is based on 'membrane-pump theory' (MPT), the crucial functional contribution of water (and changes of its physical state) and of O₂ and diffusible ROS (DROS) are entirely neglected. More correct mechanisms of membrane functioning must urgently be considered. In part 1 (1) of this double review 16 unsurmountable arguments (there are more!) were given that definitively ascertain that the idea of ion pumping is a fairy tale. Next, alternative mechanisms are described that can explain four membrane functionalities which in the classic view are allocated to depend on ion pumping. These four reinterpreted functionalities are: solute distribution between two compartments separated by a membrane, with particular emphasis on cell membrane, ion and solute transport, control of cell volume and oxidative phosphorylation. The fifth topic traditionally *thought* to depend on ion pumping, namely cell potentials, was not treated because its discussion would be too lengthy to take it up in part 1. It is the subject of the present part 2.

Here argumentation against MPT will not be repeated, neither will be the presentation of two extensive alternative theories: the association-induction hypothesis (AIH) of Ling [2,3] and the murburn concept of Manoj [4-8] that together form the core of another understanding of bioenergetic [7] on which WMMM is based [1]. The reader is urged to read the appropriate pages of part 1 or the references given above. Just two arguments will be repeated. First, equilibrium distribution coefficients of 32 different neutral substances partitioning between resting muscle cells and the surrounding Ringer for substances with 3 or more C-atoms are below unity, the lower the larger their molecular size. For raffinose it is only 0.10, which is lower than partitioning of this compound between a gelatin gel and a Ringer solution [9]. This points to orientation and polarization of the cell's macromolecular polarizing templates properly; the entire cell is polarized as evidenced by polarization microscopy [10,11]. These experimental data ascertain that concentration gradients may not be described by Nerst equation for diluted '*ideal*' solutions as done in the individual terms of the Goldman-Hodgkin-Katz equation.

Instead, laws of colloid science (AIH), electrochemistry (murburn) and other physicochemical laws must be applied. In the WMMM the concept of ion pumps is totally absent. Proteins called '*pumps*' appear to act according to completely different physical-chemical principles, as explained in part 1 [1]. A second argument follows from experiments with resting muscle cells, which despite an incomplete cell membrane (transversally cut cells with the open end in contact with Ringer solution, the closed end hanged up in moist air) keep their Na⁺ and K⁺ concentrations for at least two days [10]. This assures that the resting (sub-threshold) state is a long-term meta-stable high-energetic equilibrium of physical forces, not a metabolism-dependent active process as erroneously *assumed* by MPT. Clearly, respiration and/or glycolysis are only needed to restore the resting state during the refractive period.

In what follows the well-known '*classic*' and still-instructed work of Hodgkin, Huxley and Katz [13-15] and the earlier work of Goldman [16] is considered common knowledge, so that focus will be on some of its weak points. For an extensive review of its weaknesses reference is made to some recent in dept reviews [7,17,18] and some old ones [19-21]. The alternative presented by Manoj et al. [7] is focused on the production of anionic DROS and other anions (for instance OH⁻) (together abbreviated ADRS) near the membrane, which leads to effective charge separation (ECS). In contrast to many other studies, the emphasis is on ECS rather than voltage (Ψ , $\Delta\Psi$) because with the same voltage a large or a small power output can be obtained dependent on the current being large or small. Remember that a human's hair can be electrostatically loaded up to high voltage without producing much current upon discharge. ECS is a measure for a loaded capacity (a battery), and that's what matters. However, one should keep in mind that publications on the murburn concept are intended to present this concept to the readership, and this intention may obscure that other processes might be at work too. It is the aim of this review to present the many different aspects of ECS and potential behavior near membranes. Hereby it should be noted that a distinction must be made between *chemical power output* for those aspects of the membrane that act as an electrode (murburn aspects) and *physical power output* which can be substantial too in case of high charge density of fixed charges on the membrane surface(s) – which is the case – and whereby charging and discharging occur through the physical processes of desorption and adsorption of counterions (AIH). One must also consider the capacitive properties of the macromolecular part of the membrane and how water impinges on it (*wet*

membrane – AIH [19], and Pollack's 'exclusion zones' – EZ [20]). Ideally, one should arrive at an overall thermodynamic description [18,21], the ultimate goal.

Because the Hodgkin-Huxley-Katz (HHK) model is still widely instructed, the discussion must start with it.

1. HODGKIN-HUXLEY-KATZ MODEL AND GOLDMAN-HUXLEY-KATZ EQUATION

The investigations of Hodgkin, Huxley and Katz [13-15] are a monument that established that adaptable Na^+ and K^+ currents together with membrane capacity are involved in cell potential and changes thereof known as generator potentials and action potentials. These findings opened the path towards an unprecedented enquiry of the ionic electrical properties and processes taking place at the cell surface. Meanwhile almost 75 years elapsed during which a number of ideas which did not agree with the HHK and GHK explanation were published, but were unable to change a kind of '*once and forever established consensus view*'. Experimental data obtained by Hodgkin, Huxley and Katz are not denied; the interpretation however is. Cell potential related phenomena are more complicated than they proposed, as indicated by themselves though they were not able to figure out how; and that is due to the erroneous general theoretical concept that they used to interpret their results, namely membrane-pump theory (MPT). The MPT idea was gaining credibility those days, not the least because it was much more quantitative than any other model. Reciprocally the HHK-model, quantitative too, largely increased acceptance of MPT.

Central in the HHK model is the selective permeability of the membrane for specific ions. Hodgkin and Huxley experimentally demonstrated how the inward and outward fluxes (ionic electrical currents) of Na^+ and K^+ were related to changes in cell potential. Originally the participation of other ions was considered (Cl^- and others). They conjectured that the relation between measured membrane potential, concentration gradients of the involved ions and the permeability of the membrane for these ions could be captured by the earlier work of Goldman [16], which resulted in the Goldman-Hodgkin-Katz (GHK) equation. They applied the idea that the concentration gradients of these ions could be calculated by means of their respective Nernst equations. However, just this way of calculating suffices to disqualify the GHK explanation on behalf of all arguments given in part 1 [1] and many others presented below. In addition they did not consider: (i) phase transitions [2,3,19] (they followed the '*only one phase*

assumption' of MPT), (ii) the effects of changes in the structure of water upon surpassing threshold potential [2,3,19,21] (they were sticking to MPT's '*just normal water*' idea), (iii) changes in ion activity coefficients [2,3] (they followed MPT's idea of ions '*always in solution*'), and (iv) ignored redox effects due to O_2 entering the reduced interior of the cell (murburn concept [4-8]). The latter was discovered only about 60 years later; no one thought of the central roles of DROS before!

They studied both the voltage and ion current questions. From these 2 approaches merely the voltage question was picked up later by others. Mitchell [22] too looked more to voltage ($\Delta\psi$) than to the build-up of charge. In contrast, '*effective charge separation*' (ECS) stays at the heart of Manoj's murburn concept [4-8].

The GHK equation for the rest potential is:

$$\Psi = (RT/F) \cdot \ln[(P_{\text{Na}}[\text{Na}^+]_{\text{out}} + P_{\text{K}}[\text{K}^+]_{\text{out}} + P_{\text{Cl}}[\text{Cl}^-]_{\text{in}}) / (P_{\text{Na}}[\text{Na}^+]_{\text{in}} + P_{\text{K}}[\text{K}^+]_{\text{in}} + P_{\text{Cl}}[\text{Cl}^-]_{\text{out}})] \quad (\text{eq.1})$$

with P = permeability coefficient of the membrane for the appropriate ion, R = gas constant, F = Faraday constant.

In the aftermath of their proposal the relation between potential and external Na^+ and K^+ concentration was supported by experimental evidence. That with internal Na^+ and K^+ concentration was studied by means of closed axoplasm-free axon membrane sacs from starfish giant axons filled with experimental salt solutions, but this did not give equivocal data (reviewed by Ling [19]). Finally, experimental verification of the Cl^- term gave anomalous results. This term was subsequently discarded deliberately [23], which lead to the truncated GHK equation.

$$\Psi = (RT/F) \cdot \ln[(P_{\text{Na}}[\text{Na}^+]_{\text{out}} + P_{\text{K}}[\text{K}^+]_{\text{out}}) / (P_{\text{Na}}[\text{Na}^+]_{\text{in}} + P_{\text{K}}[\text{K}^+]_{\text{in}})] \quad (\text{eq.2})$$

It is important to capture that HHK theory and the GHK equation cannot bring an overall understanding of electrophysiology because of their one-sided approach, which restricts measurements and theoretical thinking to the ion-based electrical aspect, leaving behind the electronic, mechanical and thermodynamic aspects, including the remarkable absence of heat output during an action potential [24]. First, some amendments to the electrical aspects of HHK theory and GHK equation will be discussed, and then the thermodynamic and mechanical aspects will be disclosed as being most essential.

2. SEMI-CONDUCTION HYPOTHESIS OF COPE

Central to HHK theory and GHK equation is the idea that ion

currents are considered as currents of ions which are *free* in solution (MPT). The '*free*' aspect has been questioned by Cope in his '*semi-conduction hypothesis*' [25-30]. He adapted the Elovich equation used to describe semi-conductive electron currents in electronic devices (transport of only one type of charge-carrier: electrons together with holes) to biological systems with several charge-carriers (cations in combination with holes) [25]. He then applied the adapted equations to data from his own, from Hodgkin and Huxley, and from other literature used to confirm the HHK-model based on free ion currents. This allowed him to demonstrate semi-conduction in nerve cells [26-30]. Using Rb^+ as an analogue for K^+ he elaborated that an n-type mechanism applied when the nerve cell is clamped at the resting potential, and that a p-type mechanism takes over when the cell is clamped at an active potential, for instance zero potential [29]. This change of mechanism is to be expected when phase-transitions would be involved upon surpassing threshold potential. In experiments using *Myxicola* single axons clamped at -100mV with and without tetrodotoxin Cope [29] showed that also the Na^+ repolarisation current conformed to the Elovich equation. Together this demonstrates that above threshold Na^+ as does K^+ move from one fixed charge to the next, and holes move in the other direction.

Cope [29,30] applied another equation and method used in physics to detect phase transitions, namely Avrami analysis, and applied it to the original experimental data of Hodgkin and Huxley [14] on axonal K^+ conductance during the action potential. The results disproved the *assumption* of free ion currents and demonstrated the involvement of a 2-dimensional (not 3-dimensional) phase transition upon surpassing threshold potential. The cylindrical shape of axons and the fact that ion currents anyhow pass through the membrane in a two-dimensional direction (circular cross section of the axon) implies that there is no cation movement along the length axis of the axon. Insofar, the third direction of ion movement along the length axis, as it is '*supposed*' in classical understanding of action potential propagation, is not available. This conclusion at once eliminates the necessity to give an answer to the *mystery* of how in myelinated axons the action potential '*jumps*' from one node of Ranvier to the next; there just are no ion jumps. The latter conclusion entirely fits with the understanding of action potential propagation according to the murburn concept [7] (section 5) and the thermodynamic approach [18] (section 6).

There is no fundamental difference between Cope's semi-

conduction mechanism and Ling's proposal of a hopping '*adsorption-desorption transport mechanism*' [2] other than that the first mechanism invokes the existence of unoccupied sites (holes), about which Ling is silent only because he focusses on the adsorption-desorption process (he knew the work of Cope, they had similar ideas but used other approaches). They also believed that ion displacements were due to an underlying movement of electrons through the macromolecular lattice. Ling [2] focussed on Lewis inductive currents and Cope on electron-phonon coupling [31]. Hereby electron conduction is linked to mechanical vibrations (phonons) of the (macro)-molecular structure, the material lattice. Above threshold this coupling leads to dispersion-less conduction of the electron-phonon effects, known as '*polarons*', for which Cope found that this mechanism is applied by life in many different processes [31,32].

There are a number of mechanisms that substantiate the possibility of non-dispersive propagation of '*Lewis induction coupled to moving lattice (molecular) vibrations (phonons)*' in certain protein secondary structures: α -helices in an apolar environment [33], folding-unfolding of dynamic α -helices with effects on water polarisation [2,3]. The conduction velocity of the involved electrons is slowed down due to coupling with the much slower mechanical vibrations (phonons). *Ab initio* calculations arrive at 100m/sec [33], equal to the maximal propagation velocity of action potentials in myelinated axons. These mechanisms show that cation currents are not the primary reason of action potential propagation. Ion currents are the consequence of electron conduction, an idea which is central also to the murburn concept [34,35].

3. ADSORPTION POTENTIALS?

The GHK equation also holds that the potential is determined by the relative strength of the permeability coefficients of the involved ions multiplied by their concentration gradient. However, the Cl^- term had to be eliminated and there was no experimental agreement with internal Na^+ and K^+ concentrations. Hence the sole experimental data that conform to parts of the GHK equation are those of measured potential in function of variation in external concentrations of K^+ and Na^+ , which makes that the idea of Na^+ and K^+ gradients, which de facto implies two compartments, is not corroborated.

And, what about the permeability constants for Na^+ and K^+ ? They were still waiting for experimental corroboration until Edelmann [36] performed an experiment, whereby resting potential was measured in function of different

concentrations of external K^+ , alone and in the presence of its analogues Rb^+ and Cs^+ , after he had first established that the order of permeability coefficients of these ions is $P_{Rb^+} > P_{K^+} > P_{Cs^+}$, and that of the adsorption constants is $K_{K^+} > K_{Rb^+} > K_{Cs^+}$. Edelmann then found that measured potential only conformed to the obtained graphs when adsorption constants were introduced. It can be concluded that below threshold at least two factors may change potential (may produce generator potentials): changes in external Na^+ and K^+ concentrations (among which K^+ by far has the greatest impact) and changes in their adsorption constants. These may change due to a combination of different stimulatory and inhibitory factors having influence upon them, and in this way allow to produce generator potentials. Note that the view of Manoj et al. [7,35] is broader insofar that not only adsorption equilibria (for water and ions), but also murburn reaction and co-solvation equilibria appear to be involved (section 5.3). Anyhow, Edelmann's results corroborated an equation previously developed by Ling in 1959 [37], namely:

$$\Psi = \text{constant} - (RT/F) \cdot \ln(K_K[K^+]_{\text{ex}} + K_{Na}[Na^+]_{\text{ex}}) \quad (\text{eq.3})$$

with K_K and K_{Na} the respective adsorption constants for K^+ and Na^+

This equation and the experiment of Edelmann do not mean that internal concentrations of these ions (better: concentrations multiplied by changeable activity coefficients, as activities are not constant) do not have an influence. They are just not taken up in the equation. Their experimental study will be very difficult *in vivo* because of the complexity of intracellular situations, whereas closed axoplasm-free axon membrane sacs used to study the influence of internal ion concentrations are too simple a model of reality.

Comparison of GHK equation and Ling's equation as done in the experiment of Edelmann [36] and in some later studies by Thoke et al. [38] and Tamagawa [39] show how prudent one has to be about interpreting data in agreement with the mathematics of a given equation used to fit physiological data points on a curve because permeability coefficients (HHK) and adsorption constants (Ling, Edelmann) are mathematically and dimensionally similar, yet are linked to entirely different physical processes. One must always look to the physics.

Another question concerning Ling's equation 3 is: what is the meaning of the constant in Ling's equation? Details are given further (section 5). Here it can be stated already that it must conform to the lowest possible potential (hyperpolarization) from which the terms containing the adsorption

constants must be subtracted to arrive at a potential that brings about some depolarization in the direction of threshold potential, which includes resting potential and generator potentials. In agreement with the results of Ling's open-ended muscle cell experiments [10] the entire range of potential values between hyperpolarization and threshold potential (i.e., resting and generator potentials) should be equilibrium-based. This makes below-threshold processes very sensitive and algebraically summative within a limited region and period of time. These limits are due to the normal effects of dispersion. The integrating of different influences (equilibrium-based effects) makes changes in electrical capacity below threshold potential essentially '*analogue*' in nature.

Ling's simple equation (eq. 3) for the resting potential was further developed by him later in a way that cooperative aspects of changes in adsorption potential can be studied quantitatively by means of equation 4 [2,19], which is derived from the Yang and Ling cooperative adsorption isotherm [2,19,40] (see part 1):

$$\Psi = \text{constant} - (RT/F) \cdot \ln[1/[K^+]_{\text{ex}}[1 + ((\xi - 1)/(\xi - 1)^2 + 4\xi \exp(\gamma/RT))^{1/2}]] \quad (\text{eq.4})$$

with ξ as a term related to the exchange of an adsorbant j for i , and given by the product of the external concentration ratio $[p_i]/[p_j]$ times $K_{j \rightarrow i}^{00}$ the equilibrium adsorption constant of exchange of j for i ; with $-\gamma/2$ as the nearest-neighbor-interaction energy inductively transmitted from one adsorption site to a next one of the same type, whereby 2 in the denominator arises from the fact that in a series of adsorption sites there are often 2 neighbors, one behind, one in front.; and $-\gamma/2$ is given by:

$$-\gamma/2 = \tau(-\Delta F_{j \rightarrow i}^{00}) \quad (\text{eq.5})$$

with τ = transmissivity constant of Lewis induction and $\Delta F_{j \rightarrow i}^{00}$ = free energy of exchange adsorption (i replacing j).

Since the dimensional content of the concept of energy contains time, the isotherm presents not only a state but tells something about the process of Lewis induction. This means that it goes beyond ion exchanges, instead assesses the underlying causes of such exchanges. They must be sought at the level of electron displacements as they occur during Lewis-induction. The extreme case of Lewis-induction is that an electron would leave its corresponding atom and get involved in electron transfer, i.e., in redox activity. That case is treated in section 5; it forms the core of murburn mechanisms. Insofar both the AIH and murburn concept are delving deeper than HHK, which exclusively looks to ion displacements. The latter discern electron displacements as the ultimate cause. Other equations of cell potential can say nothing about currents,

though they are often interpreted as such. Severe critiques of the latter misinterpretation were presented by Manoj et al. [7,35] and Delalande et al. [17].

Ling [2,19,41] (equation 6) added a third term to equation 4 for description of the above-threshold phenomena (action potentials). It consists of a diffusion potential, which vanishes when the resting state is restored at the end of the refractive period because the resting state is an equilibrium state without net diffusion in a particular direction. The main difference between this action potential term and the HHK model is that instead of total intracellular Na^+ and K^+ concentrations activities are introduced, in agreement with experimental data for a phase transition upon surpassing threshold going along with changes in activity coefficients. HHK theory is silent with respect to these subtleties because it follows the MPT paradigm of '*only free ions*'. The general equation for all potentials then becomes:

$$\Psi = \text{constant} - (RT/F) \cdot \ln[1/[K^+]_{\text{ex}}[1 + ((\xi - 1)/[(\xi - 1)^2 + 4 \xi \exp(\gamma/RT)]^{1/2})]] + (RT/F) \cdot \ln[a_{\text{Na}} \cdot [\text{Na}^+]_{\text{in}} + a_{\text{K}} \cdot [\text{K}^+]_{\text{in}}] \quad (\text{eq.6})$$

with a_{Na} and a_{K} as the activity coefficients of Na^+ and K^+ .

4. PHASE BOUNDARY POTENTIALS AND EXCLUSION ZONES: POLLACK

Next, the involvement of water in setting up a potential must be discussed. It tells something about the potential at a moment in evolution that there were not yet membranes. Zheng and Pollack [42] developed a method to observe the surface of synthetic hydrophilic polymer gels, gelatine gels, and cell surfaces (resting muscle cells [20]) by bringing them into contact with pure water in which microspheres are suspended which are visible in the light microscope. In all cases studied a clear exclusion zone (EZ) without microspheres was observed between the gel or cell surface and the bulk phase with microspheres. The extent of the EZ can be quite large, about 200 μm for polyacrylate gel and muscle cells and 500 μm for Nafion. Because of this extent a number of parameters could be determined in function of the distance from the polymer/gel/cell macromolecular surface, namely profiles of NMR relaxation time [43], polarization via polarization microscopy [11,20], 10 times higher viscosity [20], higher refractive index indicative of higher density [44], pH [45], electrical potential and ECS [46], IR, VIS and UV absorption and emission spectrum [20,47].

The observed NMR relaxation times are indicative for high order in the EZ. The high viscosity agrees with this.

Polarization micrographs directly reveal the high polarization of water in the EZ. Together these characteristics are indicative for polarization over an astonishing number of layers of water. The absorption peak at 270nm points to strong excitation resulting in delocalized quasi free electrons. The excitation corresponds to the presence of electrons at an excitation level at 12.06 eV from the ground-state, i.e., close to 12.60 eV, which marks ionization. The boundary potential, corresponding to the steep part of the potential curve near the EZ/bulk phase border tells that something happened to the expected electrical double layer that is normally found close to a surface with fixed charges, but which here appears to be displaced to a location at great distance from the macromolecular surface. This must be explained by the presence of the many intervening layers of polarized and oriented water. The data from potential measurements raise an important question about eventual power output (the product of potential and current). Does the observed potential-drop at a location far from the molecular surface constitutes and behaves as a loaded battery, or is it merely an incidental by-product of EZ formation? pH in the bulk phase close to the EZ/bulk-phase border was shown to drop to a value of about 2. Does this constitute a real battery? To answer this question Pollack [20] inserted one electrode in the EZ and the other in the zone beyond and connected the two electrodes through a resistor demonstrating that the stored charges start to produce an initial current of about 4 μA , falling to about 1,5 μA after 1 to 1,5 minutes and then remaining constant at that level (7 minutes measured in total). This assures that the EZ functions as an important ECS able to drive cellular processes. The question then arises: From where does all this stored energy come? Only from the fact that the outer surface of the gel/cell possesses a high density of fixed charges?

Observations over long periods of time also demonstrated that this boundary potential is stable for many hours. It slightly degrades during the night and increases again at the onset of the day [20]. This appears to be linked to the other remarkable observations, namely that the EZ shows increased photon absorption in the IR, VIS and UV in combination with decreased emission [47]. The absorption peak at 270nm (UV) is indicative of a high excitation level of the electrons of the O-atoms of the polarized water molecules in the EZ, representing the huge amount of stocked negative charge of the EZ with the excluded protons just outside the EZ as the other pole of the battery. There is also increased absorption in the mid-IR where the major absorption broad-bands of water

are situated (ν_1 : O-H stretching at 3657cm^{-1} , $2.734\mu\text{m}$, and ν_2 : H-O-H bending at 1595cm^{-1} , $6.261\mu\text{m}$) indicative of some structural changes in length of the O-H and hydrogen bonds as well as of the angle between the O-atom and its bound H-atoms. The fact that the EZ remains largely intact during the night leads to the conclusion that the high order of the EZ and its ECS is to a large extent maintained by uptake of IR energy from the temperature bath. This implies that IR-energy present at environmental temperature gets transformed into both charge-separation [20,46] and production of low entropy [20,43]. In physical terms Voeikov and Del Giudice et al. [48] explain that thanks to the long-term stability (can be days) of the EZ, water is able to transform in a cumulative way: “*n quanta of frequency ν into one quantum of frequency $n \cdot \nu$* ”.

This conclusion appears to contradict classical (macroscopic) thermodynamics since the energy to dissociate water is more than the IR-energy absorbed. But at the quantum level it is allowed, as could be derived by Del Giudice et al. [49] from non-linear quantum field principles provided that resonances with quantum vacuum vibrations are taken into account, as it should be, but was not done previously (see also Ho [12]). The *ab initio* derivation revealed that even normal/bulk water is a 2-state liquid and can contain quite stable polarized coherent domains (CDs) of up to about 100 nm in size, existing within a non-coherent main phase [48-52]. In bulk water such CDs are a minor constituent, but they become the majority near certain hydrophilic water-polarizing macromolecular surfaces, which are abundantly present in the fluid phase of cells and at membrane surfaces [1-3,20]. There connection with the quantum vacuum means that CDs can tap energy from the aether's quantum fluctuations and this should explain from where the energy for loading the EZ-battery stems and why it remains so stable. The derivation that all water molecules in the EZ are highly ordered and oscillate at a common frequency makes that all its associated quasi-free electrons form a kind of coherent rotating plasma, considered by King [53] as the necessary requisite to extract energy from the vacuum (aether), also known as ‘zero-point energy’. So, it appears that life has a double energy input: energy from the sun (photosynthetic organisms) or food (heterotrophes, indirectly from the sun), and energy directly from the temperature bath (also electromagnetic energy, but of a lower frequency, whereby appropriate quantum fluctuations are recruited to build up water CDs. Voeikov and Del Giudice [48] calculated that in water-CDs some electrons are so excited that this kind of water structure becomes a strong electron donor. They speak about

‘water respiration’, and they see water CDs as a very early and primary reductive agent in the onset towards pre-biotic life. In his latest review Del Giudice et al. [51] remarked that the directly observed properties of Pollack's EZ structure correspond to the calculated properties obtained from their own non-linear quantum field approach.

But what is the structure of water in EZs? And does it conform to Ling's ‘polarized oriented multilayer water’ (POM-water)? Pollack [20] proposed that under the influence of suitable water-polarizing hydrophilic surfaces water may undergo another kind of dissociation than the usual one, namely one which generates $(\text{H}_{1.5}\text{O})_{6n}^{3n-}$, a kind of highly excited but quite stable negatively charged flat multi-hexagon water ‘polymer’, whereby excess electrons are delocalized, highly excited, and lead the enhanced dissociation of $3n \text{ H}^+$, which get excluded from this complex. Pollack calls this 3D-structural model “*the fourth phase of water*”, a likely model for water in an EZ. Note that also carbon atoms with the normal tetrahedral configuration can reach a highly excited flat transition state condensing into stable flat graphite's multi-hexagon structure. Obviously, if Pollack's structural model would exist, it should be characterised by a density above that of normal water, which is indeed observed [44]. In addition, the existence of structures with a H:O ratio of 1,5 were found [54] together with numerous observations of multi-hexamers and an absorption peak at 270nm (references in [20]). These findings are difficult to reconcile with other alternative hypotheses which try to explain formation of EZ on behalf of more classic mechanisms [55,56]. This does not mean that those hypotheses may not contain elements of truth with respect to the large width of the EZ, though Pollack's group proposed a model of their own to explain the EZ's extent [57]. It was suggested [58] that when water-polarizing templates polarize water insufficiently strong (insufficient Lewis effect), the model of polarized water from Chaplin [59] known as ‘low density water’ (LDW), in which the tetrahedral structure of water is maintained, may apply. However, when a Lewis-inductive threshold is surpassed, Pollack's ‘fourth phase water’ (equal to water-CD) is formed, which because of its lower H/O ratio has a density that is higher than that of bulk water. This suggestion is in line with the early suggestion of Linus Pauling [60] that the O-H bonds and the $\text{O}\cdots\text{H}$ hydrogen bonds can be considered as a ‘resonance structure’ midway between a polarized covalent bond and a hydrogen bond, somehow comparable to the resonance structure of the bonds in benzene, which are mid-way between the single and double

bond. The possibility of a flattened highly excited structure of water was theoretically derived and practically applied by Kanarev [61] on behalf of his very performing new atomic theory (which might be a treasure for biology [62]).

Ling defines his POM-water model by the mechanism of its formation [2,3]. If (1) the topology of (partial) charges of a hydrophilic crystal, polymer, biomolecule, larger biological system such as a membrane or cytoskeletal element is such that it fits the topological distribution of partial charges on adjacent water molecules, and if (2) the Lewis inductive influence of such polarizing templates is sufficiently large (surpasses a certain energetic threshold), then the first layer of water molecules will orient and polarize water into many layers. Ling does not give a structural 3D-model corresponding to his mechanistic description, which goes back to the early 1960^{ties}. Though Pollack advocated Ling's POM-water idea for long, he named it a '*dipole model*', after he discovered the remarkable properties of EZs (collected in his book from 2013 [20]). Clearly his structural 3D model of fourth phase water tells more and differs from Ling's view. Therefore, it is adopted in this review (see arguments given above). Yet, I reasoned [58] that: (i) since EZ-water is directly observed by Pollack at the outer face of cell membrane and near gelatine (which can be seen as analogous to IDP's, i.e., both are unfolded polypeptides), and (ii) since Ling concluded to the existence of POM-water on both sides of the membrane and in cytoplasm (on behalf of physiological data), the logical conclusion follows that *at those locations* the terms EZ-water and POM-water go about the same structure/phenomenon, but the two investigators highlighted (partially) other properties because they used other methods of investigation, hence the properties of both scientists are additive *at those locations*, and because Ling does not give a 3D structural model and Pollack's 3D structure of fourth phase water is experimentally well-underpinned already, the latter 3D model must be adopted as long as no better model is formulated. The two important points in the reasoning of Ling, however, are (i) that not every hydrophilic molecular surface produces POM-water (AgCl, polyethylene oxide, unfolded polypeptides do, ZnI₂, polypropylenoxide, many globular proteins do not because the topology of their partial charges does not fit), and (ii) that the polarizing template must surpass an energetic threshold (be sufficiently inductive). The latter means that in cells there might be other situations, where induction is insufficient, but nevertheless water polarization takes place. It was conjectured that at those locations water gets polarized but keeps tetrahedral structure.

The presence of a boundary potential at the EZ/bulk-water interface made Trevors and Pollack [63] to suggest that: (1) resting cell potential is localized at some distance from the membrane's protein-lipid outer surface, and (2) that during the pre-biotic era the coacervate precursors of life (comparable to experimental Fox-like microspheres) may have possessed an EZ with an associated phase boundary potential in the absence of a membrane, hence (3) that a complex system with pumps for potential generation cannot be the explanation for the existence of a potential at the cell membrane (and other membrane types). It is also evolutionarily not feasible as it would imply that evolution had to wait for the appearance of a membrane with a very complex protein machinery for pumping ions before an electrogenic pump-dependent potential could have originated (this reasoning applies to both Na/K-ATPase, Ca-ATPase and redox-complex-dependent proton pumping [1]). In reality, pre-biotic membrane-less coacervates with predominantly negative fixed charges (Asp and Glu residues) must already have possessed a boundary potential, negative for the EZ, positive for the adjacent bulk water phase, just because the outer surface contained negative fixed charges that polarize water as they are present also inside the coacervate, where they also polarize water. This is a simple mechanism since also the surface of a polyacrylate gel exhibits such boundary potential. It is invoked here that when at a later stage a membrane with an excess of negative fixed charges is formed just beneath the coacervate surface, those fixed charges take over the properties of the previous coacervate boundary. But, since a membrane is two-sided, this also opened new ways to modulate the original boundary potential. This includes that an eventual potential jump may exist at the inner surface of the membrane as well (section 5) and, if the membrane is asymmetric (inner and outer leaflet of different composition), this leads to a capacitive form of charge separation on its own (section 6). The insertion of a membrane just beneath the coacervate surface may also bring about changes in the distribution of DROS (with the possibility to generate electrode potentials (section 5), which were already present in the coacervate before.

5. ELECTRODE POTENTIALS AND MURBURN CONCEPT (MANOJ)

The question must be posed if the potential includes a factor that corresponds to an '*electrode potential*'. Kell [64] advocated an electrodic mechanism for potential development at mitochondrial inner membranes, which should apply also

to prokaryotic cell membrane and thylacoid membranes. However, his entire argumentation in his own words rests on: “Accepting the widely held view that transmembrane phase proton gradient is intimately involved as an intermediate in electron transport phosphorylation”. This idea has been rejected above on sufficient grounds in part I [1]. Insofar only recently a confirmative answer to the possibility of an electrode potential was given with the emergence of the ‘murburn concept’ of Manoj [5-8,34,35]. This new concept finally resolves a long series of anomalies in the entire field of redox biochemistry and electrophysiology by disclosing the physiological roles of DR(O)S at low concentrations. The mechanism is simple. The formation of anionic DROS radicals and other anions (ADRS) in the radical mix due to reaction of 1-electron donors (redox complexes, oxidases in other membranes) are responsible for effective charge separation near the side of the membrane where the electrons are donated. For the eukaryotic cell membrane this means that oxidases such as NADPH oxidase and others are the ultimate membrane components for setting up $\Delta\Psi$ linked to full load of the membrane’s battery.

Very recently Manoj et al. [7] developed an equation, which typically focuses on the contribution of anionic radicals and anions produced in the radical mix, and which are indicated as anionic diffusible reactive species or ADRS:

$$\Psi_{\text{redox}} = (-RT/F) \cdot \ln([ADRS]_{\text{in}} / [ADRS]_{\text{out}}) \quad (\text{eq.7})$$

It is proposed here: (1) that 1-electron donation to O_2 by membrane-bound redox complexes at the inner face of the membrane should lead to the largest ECS and energization level of the membrane with the corresponding highest level of

hyperpolarization, the highest $\Delta\Psi$ (supposed that the outside ADRS concentration is negligible), (2) that this electrode potential may correspond to the ‘constant’ that figures in Ling’s equations 3, 4 and 6, (3) that other kinds of processes that influence the potential are subtracted from this largest $\Delta\Psi$ value, which results in a lower $\Delta\Psi$ (more depolarized value), and (4) that in an undisturbed situation all involved equilibriums stabilize at resting potential (slightly lower $\Delta\Psi$ than the largest hyperpolarization level). Identifying equation 7 with the constant in the equations of Ling further establishes that the electron currents associated with the build-up of the ADRS-dependent ECS (with accompanying largest $\Delta\Psi$) constitutes the ‘primary’ electrical energizing mechanism of membranes. This also directly proves that electrons are the primary causative agent, and that ion flows are a consequence of it.

As told in the introduction, there are two kinds of ECS which differ in extent of power output during discharge: ‘chemical’ due to redox activity (murburn, first term in the equation 6) and ‘physical’ due to adsorption/desorption of ions (second term in equation 6) and of water (third term in equation 6). According to Ling’s AIH the two adsorption/desorption mechanisms depend on ATP [65,66]. Power output of them is limited by the amount of adsorption energy during ATP binding to the involved system. This amount is much less than that of partial chemical discharge of only one of the many radical reactions in which ADRS become neutralised (third reaction of the table). Moreover, in the radical cascade several reactions (the first two in the table) take place which emit energy, while keeping the ECS intact as can be seen from the charge balance of the reaction. In

Table 1. The amounts of energy (incomplete as these are not the only reactions) that can be stored in an ECS that is formed by a murburn process in comparison to the (maximal) amounts that can be present in a system that would be energized solely by ATP adsorption to an ATP-binding protein.

• Some murburn reactions that occur in the radical cascade and whereby the concentration of ADRS is maintained:		
$\text{O}_2^{\cdot-} + \text{H}^+ \rightarrow \text{HO}_2^-$	-322 kJ/mol	[8]
$\text{O}_2^{\cdot-} + \text{OH}^* \rightarrow \text{OH}^- + \text{O}_2$	-197 kJ/mol	[8]
• Example of a murburn reaction whereby ADRS are neutralized, corresponding to discharge of part of the ECS:		
$2 \text{O}_2^{\cdot-} + 2 \text{H}^+ \rightarrow \text{H}_2\text{O}_2 + \text{O}_2$	-176 kJ/mol	[8]
• In comparison ATP adsorption energy to lift the end-action state of a cyclic process again into the high-energetic A-state. The exact amount of energy depends on the kind of ATP-binding protein. Values are for:		
actomyosin:	-39,7 kJ/mol	[65]
G-actin:	-46,0 kJ/mol	[66]

another way these considerations establish the primacy of the murburn mechanisms.

The murburn statement of electrons as primary charge carriers may not be misunderstood as a *pure* electron conduction. It takes place in a complex colloid-like material consisting of molecules, ions and radicals, which also exhibit mechanical vibrations (phonons). There is some coupling between electron and phonon conduction, which in systems above threshold becomes self-propagating and dispersionless (polarons) as shown by Cope [31]. The equilibrium-based murburn explanation agrees with the n-type cation transmembrane transport of Cope [28] below threshold. However, also the flexible mechanism of cation transport executed by NKA and KcsA as proposed by Manoj et al [7] and in the model for NKA detailed in part I [1], which both include stochastic processes, is compatible with the p-type mechanism of Cope [28] which is not strictly deterministic too.

An interesting proposal for an intra-membrane long-distance electron conduction is that the topology of membrane bilayer lipids (a membrane lipid conformation that is formed at the onset of the A-state) is such that the double bond of cholesterol can connect to the double bonds of unsaturated fatty acid residues of phospholipids and together form a multi-molecular conjugated system [67]. Membrane phospholipids and cholesterol are involved in voltage sensing in NKA and KcsA [68,69]. This implies that they have a function in overall phase transition of the entire membrane (as all components of the membrane are involved in action potential propagation), otherwise these voltage-sensitive membrane proteins should act on their own. In view of the electron conduction through the above-threshold bilayer, and since a group of arginine residues are operating in voltage sensing, it is suggested here that the interaction goes beyond only voltage sensing and actually consists of a redox reactivity and long-distance electron conduction [7,35]. The central contribution of lipids may explain why a correct balance of cholesterol and unsaturated fatty acid concentrations is so important for the proper functioning of cell membranes particularly that of neurons. The precise regulatory mechanism determining membrane lipid composition is one of the great unknowns.

In addition, NKA, ion channels and membrane lipids have influence on the structure of membrane-associated water [1-3,7,35,68,69], which then may have a link with the oxidation states of proteins and lipids, as they should cooperate, and also because DROS-producing oxidases should be regarded as the overlooked component of the system responsible for this

redox state, for ECS and for determining membrane potential [7,35]. There is then a crucial question to be answered: Is there a relation between O₂/DROS and the structure of water? There is, but the answer to this question will be postponed to the conclusions. For now, it is clear that membrane proteins (oxidases, NKA, ion-channels, other proteins) cooperate with lipids, water and O₂/DROS. The action potential should be understood (section 6) as one giant multi-molecular '*conformational change*' of a membrane region over a length of about 10 cm (21) (section 6) in which all components cooperate as a single unit with soliton properties (70).

Equation 7 demonstrates that external ADRS have a depolarizing effect. External ADRS can have several origins. First, presence of 1-electron redox activity at the exterior, for instance in case of immune cells attacking foreign cells by means of DROS. In that case the immune cell's potential will be depolarized and the cell may need some kind of protection against its own high DROS production at the exterior. Secondly, reactive oxygen, sulphur and particularly nitrogen species may be present in inhaled air (for instance during ozon alarm). When inhaled, they primarily affect the lungs, then the blood, from where some other tissues may be reached. Their location at the outside of cells, depolarizes cell membranes over prolonged periods, taking away the electrical protection of cells normally consisting of a strong capacity at the cell membrane. This may expose the cell interior to other harming effects. Thirdly, DROS and ADRS produced at the inner side of the membrane by being diffusible may partially diffuse to the exterior, decreasing membrane polarization. More details are needed about how hyperpolarization at the start of the refractive period evolves into a relatively stable resting potential. If this potential is too close to threshold potential (can be measured for internal organs at appropriate acupuncture points with different methods), the cell is insufficiently protected against different forms of harm, the cell's batteries are insufficiently loaded, the cell gets too easily activated implying that it exists for prolonged periods in a higher entropy state with less POM-water, i.e., with less coherence. Let's remember that Damadian developed the MRI technique after he had observed using chemical proton-NMR that water in tumour cells is less coherent than in healthy tissue [71], that Plankar et al. [72] argued that decrease of coherence precedes mutagenesis in the development towards cancer, that the photonic EM-matrix is less coherent in tumour tissue than in healthy tissue [73], and that too high ROS concentrations have been linked to several so-called civilization diseases.

6. THE THERMODYNAMIC APPROACH

The foregoing already substantiates that the question of membrane potential involves many aspects. They need to be united, and this necessitates to first look to it from the only all-encompassing, unifying approach, namely that of thermodynamics. The latter *a priori* takes all facets into account – though it cannot give the details – as it starts from those first physical principles that are universal (first and second law). It uses macroscopic measurements and follows a top-down logic. Detailed observations at the molecular level (bottom-up logic) have their own value but the conclusions drawn cannot be considered the only truth; they must be interpreted together with other detailed observations as but parts within the top-down logic [74], not often done. If integrated with other bottom-up data, the conclusions may never be in contradiction with the thermodynamic approach, otherwise it follows straightforwardly that they are wrong as Einstein told us [75]. The present review is an attempt to unify the details into the thermodynamic context, which will first be discussed in general.

From a thermodynamic point of view one can look to how phonons (mechanical vibrations of the membrane lattice structure) interact with electron (and ion) currents, and resonate with photons (electromagnetic emissions and re-absorptions inherently linked to respectively de-excitations and excitations of electrons in molecules and displacements of charged particles such as electrons, protons, ions, fixed charges on macromolecules, any particle on which Maxwell equations impinge). How all these actors perform in consonance?

6.1. Phonons and polarons

In a recent review Heimburg [21] describes the nerve impulse as a soliton (as did Scott [70]), i.e., a macroscopic excited (note: better call it ‘excitatory’) region propagating without dispersion, with properties that are influenced by thermodynamic variables including voltage, temperature, pressure/tension, and chemical potentials of membrane components, whereby all thermodynamic variables are strictly coupled in a quantitatively precise way to reach the observed ‘*multi-component dynamic coherence*’. He emphasises that such couplings are the aspect which is not seen in a bottom-up approach such as a purely molecular picture or a purely electrical picture. It is noted here that the term ‘*excited region*’ is not very appropriate, even troubling, though often used. In a physiological context it often corresponds to an ‘*excitatory state*’ (above-threshold state),

and this has nothing to do with the same word in a chemical context, where it goes about electron excitation states, energy levels of electrons on an atomic bond (the higher-levels being more excited, i.e., closer to ionisation). The latter phenomenon is a characteristic of atoms, molecules and some molecular ensembles such as for instance R-state ‘*ATP-protein-POM-water-K⁺-complexes*’, which exist in a common electronic excited state. It is advisable to use the term ‘*excited*’ exclusively for electronically excited R-state situations and the term ‘*excitatory state*’ for physiological above-threshold situations, which after power output reach a low-energy A-state. The latter excitatory state is the opposite of an excited state after which the systems must be reloaded to reach again the excited R-state. However, the power output itself (R-to-A), as does the recovery step (refractive period, A-to-R) each have *dynamically coherent* properties [76-78] and also the two combined conform to a soliton. In contrast, the sub-threshold state (resting and generator state) conforms to a *static coherent state* [76-78]. Insofar, power output (the action potential’s depolarisation and repolarisation phases) consists of the transformation of the energy stored in a static coherent system into a dynamically coherent process. The only metabolic energy input is during the refractive period, and makes use of a murburn process. It is time to see that murzymes such as NADPH oxidase in eucaryote cell membrane are an essential component of membrane of the system responsible for establishing the cell potential.

The thermodynamic approach measures the macroscopic properties of the excitatory A-state as compared to the excited sub-threshold R-state. Central in this approach is the concept of phase transitions, which implies the synchronised behaviour of many molecules (in axons over a length of 10cm) due to ‘*multi-physics*’ cooperative interactions [21]. Heimburg’s research group has made extensive studies on pure lipid membranes, which resulted in a beautiful theoretical account of the ‘*mechano-capacitive*’ properties of polarized membranes by deriving new equations of primary importance to interpret experimental results (for these equations consult [21]). The lipid membrane has the properties of a capacitor. In the HHK-model the lipid part of the neuronal cell membrane is also seen as the site of membrane capacitance as it consists of a mainly hydrophobic/insulating interior bordered by two charged plates in contact with conductive fluids full of electrolytes. In the HHK-model the membrane capacity (C_M) was considered as a homogenous planar capacitor of constant surface and thickness, according to the following linear equation:

$$C_M = \epsilon.(A/d) \quad (\text{eq.8})$$

with ϵ = membrane dielectric constant, A = surface of the membrane, and d = its thickness.

However, charges on a capacitor exert mechanical forces on the two plates of the membrane, which changes its dimensions: Below threshold neuronal membranes are thinner, have larger area, expanded length and the lipid part is a non-bilayer (now generally agreed: [80]), a phenomenon called '*electrostriction*'. Above threshold it is thicker (about 0.8-1.2 nm), it gets longitudinally contracted, has lower area and it has rather a bilayer structure. Hence threshold marks a phase transition [1-3,18,21,74,76-84]. Close to phase transition compressibility is large, so that the membrane behaves highly non-linear, i.e., a small change in voltage can result in large changes in thickness and capacitance. There are reciprocal dependencies of membrane dimensions, membrane capacitance, membrane polarisation and conductance leading to flexo-electrical, piezo-electrical, and thermo-electrical properties in the case of asymmetric membranes made of pure lipid [18] and in real membranes which are asymmetric. All these properties are just due to asymmetry properly, irrespective of detailed molecular structure.

Mosgaard et al. [18] conclude that (i) many asymmetric phenomena of lipid-membranes and bio-membranes may originate from polarization of the membrane as a whole (i.e., must not be sought in the details), (ii) the influence of applied voltage on the capacitance is small in the membrane's gel (A-state) and fluid phases (R-state) because membranes are not very compressible in their pure phases, but they become very compressible close to (and during) phase transition (piezo-electricity), (iii) the system is then also very sensitive to temperature fluctuations (thermo-electricity), (iv) the orientation of lipid dipoles can change upon lipid melting/gelatinizing, (v) dielectric susceptibility displays an extreme during transition, and conversely, (vi) if either dielectric constant or permanent polarization differ between the gel and the fluid state, a transition can be induced, and (vii) close to their melting transition pure lipid membranes are not inert insulators.

Polarity of real cell membranes is intrinsic, since the lipid composition of the inner and outer leaflets differ. The intrinsic polarity can be increased when at the inside face ADRS are formed, which may lead to ultimate hyperpolarisation. Production of these anions renders additional charge on the membrane capacitance. The charge separation at the EZ/

bulk phase must be accounted for also. Its negative pole at the EZ-side must be due to negative charges somewhere at the outer protein-lipid-glycosyl surface (including sialic acid and sulphate groups). Taken together, in the below-threshold state three sites producing charge separation have the same orientation and can be considered as serial electric sources, from outside to inside: (i) the EZ/bulk phase boundary linked to properties of water, (ii) the asymmetric membrane properly, and (iii) the production of ADRS at the inside, for which the influx of O_2 in the reduced cell interior is responsible. Clearly, water and oxygen matter to understand cellular membranes, and they interact (1-8,34,35).

Concerning action potentials, followers of MPT consider the phospholipid bilayer as the electrical insulator responsible for membrane capacitance, NKA as the electrical source that loads the membrane's capacitance and drives the passive ion fluxes of the action potential, and voltage-dependent Na^+ and K^+ channels as adaptable resistors able to change specific ion permeabilities, hence controlling specific ion fluxes leading to action potentials. Heimbürg and Jackson [85], however, discovered that even artificial pure lipid membranes (even lipid monolayers on a water surface: Shrivastava et al. [86]) can produce a potential curve that is almost indistinguishable from a neuronal action potential (similar time-dependency, frequency, and amplitude properties), provided that (similar to axon membranes) lipid phase transition between a liquid-expanded and a liquid-condensed phase can reversibly take place. Also, coacervate Fox microspheres to which lecithin is added can produce potential changes reminiscent of action potentials [87]. All this solicits a deeper mechanism for action potential behaviour than just ion currents. The latter occur but are the result of this deeper mechanism. The phenomenon depends on non-linear coupling of parameters that lead to the mechanical property of loss-less phonon-conduction (velocity of about 100m/sec, all-or-none behaviour) coupled to piezo- or flexi-electricity. Remarkably pure lipid membranes can also transport ions, and patch-clamp experiments revealed that this behaviour appears to be voltage-gated [88]. This behaviour is only present with asymmetric lipid membranes (inside and outside charge distribution different, as in biological membranes: piezo-electricity), or with symmetric lipid membranes that are curved (making them geometrically asymmetric: flexi-electricity). This lipid behaviour constitutes a crucial neglected parameter in patch-clamp experiments, which – if not recognized – may disqualify the conclusions taken from the obtained patch-clamp data,

because the voltage dependency of the lipid is comparable to that of protein channels. Therefore the principles to generate an action potential must have some simplicity that is due to general thermodynamic properties which allow that a phase transition is induced by the non-linear capacitive properties of the system: that is the new understanding.

The findings on pure lipid membranes [21,85-88] can explain the hitherto not-understood mechanism of quite different agents influencing action potential generation: anaesthetics and why they can be counteracted by factors as diverse as hydrostatic pressure and decrease in pH, why an overdose of Li^+ may lead to tremor, how tremor is related to alcohol intoxication, and how ultrasound may stimulate nerve activity [89]. However, all these properties may not be interpreted as if proteins are not involved. Apparently, membrane proteins, lipids, water and O_2/DROS cooperate and are cooperatively linked at least during action potentials. The presented general thermodynamic conditions common to pure lipid membranes, lipid monolayers and excitable cellular membranes elicit the question: What do proteins add to the properties of pure lipid membranes? A possible answer could be that they add the selectivity aspects which determine which specific regulatory factors can influence the process effectuated by the protein-lipid-water-electron-phonon- O_2/DROS system as a cooperative ensemble. They establish the linkage of this complex system to specific cellular stimuli (the sensory function) and generate the appropriate integrated cellular effects (the effector function in relation to other systems and their state). Likely, they also fine-tune the kinetics.

Indeed, in cellular membranes molecules of very different nature act together as one '*giant whole*'. One cannot understand the behaviour of one component without its connection with the other participants, and without studying their electrical, mechanical, chemical and radiative properties. This connection is lost, when molecules are extracted, purified, crystallized, and brought in an entirely different environment with the aim to get X-ray diffraction data. These data can be instructive, but they should be interpreted with caution and always within an overall thermodynamic context, and that is only rarely done.

6.2. Heat/photons

In the HHK-model Na^+ and K^+ channels are treated as adaptable electrical resistors. When a current flows through a resistor heat is produced – there is never cooling of the

environment. The remarkable fact of the nerve impulse is that no heat production was measured [24]. This observation suggests that the nerve impulse contains another factor than only electrical conduction, likely a mechanical factor. There are indeed mechanical aspects and absence of net heat production points to an adiabatic phenomenon [90]. Together the electro-mechanical behaviour of the nerve impulse emerges from the collective properties of the axonal membrane, in which a compression wave analogous to a sound wave propagates in a quantitatively and intimately associated manner with the electrical processes, together being responsible for the soliton properties of the impulse [90,74,85]. Ordinary sound is an adiabatic phenomenon, though it dissipates at the long distance. In 1941 Cole [91] already considered the possibility that a membrane is a piezo-electric structure, which implies that an applied potential difference can deform the membrane, and that a deformation of the membrane (for instance curving) can change the potential difference. The involvement of mechanical aspects is undeniably illustrated by the observation in all axons studied that thickness changes when and where the impulse passes [88]. This certifies that a mechanical pulse (phonon) is intimately connected to the electrical one. The two form one phenomenon. The electric and mechanical pulse resulting from the same stimulus must reinforce each other to explain the no-heat output, a typical property of a soliton. The propagating phonon may compensate the losses of what normally would be the dispersive character of the electric current. Conversely, propagation of a mechanical wave might disperse in the absence of an accompanying electrical component. The mechanical response was found to be proportional to the voltage change illustrating accurate coupling of the two wave forms, generating polarons, as observed by Cope [31]. In contrast, changes in below-threshold potential soon disperse. But they are also algebraically summative within a limited region and a limited period, the important property of generator potentials. These behave in a very sensitive analogue way, in agreement with the stochastic features of all the equilibria at the below-threshold level, as observed and advocated in the murburn concept.

The phenomenon of no heat output [24] may also contain a component of resonant reabsorption of emitted radiation, the central issue of the theory of biophotons [73]. Cope [35] argued for coaxial transmission of IR energy in mitochondria and nerves, whereby the volume enclosed by the IR emitting

membrane acts as a resonant cavity. The myelin sheet may be involved in this kind of resonant IR energy transport giving an explanation for the velocity of impulse propagation in myelinated axons provided that it follows a multi-step emission-reabsorption-emission pathway since direct photon radiation would be much faster.

6.3. Ionic-Mechano-Hydraulic Model

Very recently Delalande, Tamagawa and Matveev [92] introduced a HHK-opposing model in which a hydraulic pressure wave in the peri-axonal fluid (between the axon and the myelin sheet) is seen as the primary cause of action potential propagation, with ionic effects being secondary. Neurons indeed swell a little during depolarization and shrink again during repolarization. Therefore, the idea of a peri-axonal pressure wave as a physical component of R-to-A power output should be taken seriously for in vivo neuronal tissue, both for myelinated axons, where peri-axonal fluid is delineated by many layers of myelin membranes which restrict expansion, as well as for unmyelinated axons, where expansion is limited by other neighbor cells and the perineurium, but not to the same extent, which translates in lower propagation velocity. Because this reasoning does not hold for isolated non-myelinated axons without perineurium, neither for membrane models of pure lipid, the hydraulic mechanism cannot be the unique mechanism driving action potential propagation, but it must be included as one of the mechanisms among others, which together should explain action potential conduction in an overall thermodynamic way. Note that any hydraulic mechanism is supported by electron conduction, which is anyhow primary.

7. LOCATION OF CHARGE SEPARATION AND CAPACITANCE

All the foregoing indicates that determining the precise location of charge separation, its potential and membrane associated capacitance is not that simple and differs between the A- and R-state of the membrane (figure 1).

Strictly, the measured potential difference exists between the sites where the 2 electrodes are inserted. Several steps of potential jumps at different cellular locations add up algebraically between these two insertion points. From the theoretical considerations given in this review ECS and the associated potential steps may be expected at different locations: (1) usually membrane capacitance is understood to exist between the two liquid-associated hydrophilic lipid-

protein surfaces. (2) But in electrical terms the actual sites of these surfaces may be relayed further away into the fluid on one or both sides due to coherent POM/EZ-water formed and associated with one or both surfaces. At the outer face of the cell this has been directly observed [20]. (3) At the inner side of the membrane an EZ could be present theoretically during local near-membrane R-state, but likely there is continuity with POM-water present further away from the membrane. Bagatolli et al. [93] observed that metabolic oscillations in NADH/NAD⁺ and ATP/ADP ratios in the cell's interior communicate with the membrane through the continuity of the structural state of water. During a local cytoplasmic A-state a certain amount of water is transformed from POM-water into hyper-fluid (HF) water [94], but some POM-water remains [94,95]. Actually, the summated surface of water-conducts that pass through the membrane is probably only a few percent of the total membrane surface. Much of the membrane may remain lined with POM/EZ water during A-state, but that percentage must still be determined experimentally. That may also hold for the summated surface in A-state at the inner face of the membrane.

Water-filled conducts through the membrane may exist in certain proteins, in lipid regions during phase transformation, as conducts partially coated by protein partially by lipid, and there may be conducts penetrating through the EZ-layer properly, i.e. lined by surrounding fourth phase water and continuous with the above structures in the membrane. Anyhow, Ling et al. [96] and also Wheatley et al. [97] undeniably demonstrated that water-structure is what determines membrane permeability. Such water conducts through which ions can pass act as a local quenching of the membrane's capacitance. (4) Changes in membrane capacitance can be elicited by ion adsorption on the fixed charges of one or both membrane sides [36]. (5) The ECS of primary importance, however, exists between the membrane-located murzymes which donate an electron (hereby remaining more positive afterwards) and the fluid wherein ADRS are formed. All this makes clear that it is not so simple to define the extent of the Wet-and-Murburn Membrane, though the membrane clearly is 'wet' and acts in a 'murburn' way.

DISCUSSION ABOUT WMMM

Electrogenic ion pumping as the mechanism that generates the resting potential (the classic view) is a fairy tale that is totally silent about the effects of water and O₂/DROS. These

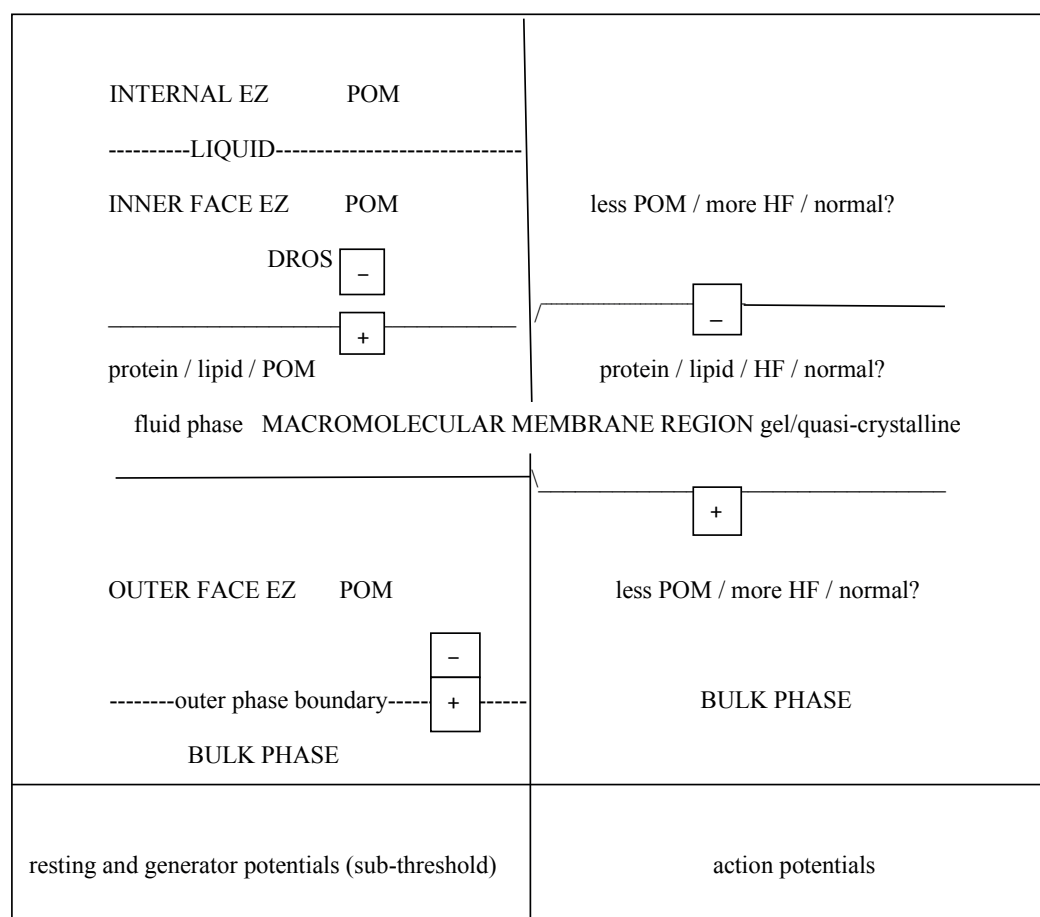


Figure 1. Location of the major potential jumps under sub-threshold and above-threshold conditions. EZ: exclusion zone; POM: polarized multi-layer water; HF: hyper-fluid water.

neglected factors are central when ECS and $\Delta\Psi$ are interpreted in the context of the WMMM. Herein electrons are the primary charge carriers, ion currents being a consequence of electron displacements. ECS and $\Delta\Psi$ are determined by several factors with murburn activity being the primary but not the only one. Murburn processes are responsible for maximally charging the 'battery' and producing the largest $\Delta\Psi$ corresponding to hyperpolarization. In the equations 3, 4 and 6 of Ling this maximal load appears in the form of the first term (the constant) from which secondary effects due to adsorption/desorption of ions (rest and generator potentials) and phase shifts due to water depolarization (action potentials) must be subtracted. The latter are mechanisms that discharge the ECS to different degrees. It is stated that the recently developed equation of the Manoj group (equation 7) corresponds to Ling's 'constant'.

All adaptive processes taking place below threshold potential are equilibrium based. They are due to changes in co-solvation, reactions taking place in the radical mixture,

adsorption/desorption, etc., processes in which besides deterministic aspects also a stochastic factor is operative. Hence, this allows for very gradual, *analogue*, dispersive algebraic summation, integration of the different effects present within a limited period of time and limited region of space. To a large extent these effects constitute what has been called the '*basal homeostasis*' level of regulation [1,5-7]. Threshold potential marks the phase transition towards the '*all-or-none*', dispersion-free, digital, frequency-coded phenomenon of the action potential as a large-scale soliton. Above threshold electron conduction reaches a level of cooperation with phonon conduction achieving that of a polaron, which is why the system becomes loss-less. This transition is not merely a question of temporarily increased permeability of the membrane for specific ions that can be allocated to specific trans-membrane proteins ('*pumps*' and channels). The phenomenon is complex and involves chemical, electrical, mechanical (phonons), hydraulic (coherent phase

shifts of water and osmotic balance) and electromagnetic (photonic) aspects, whereby proteins are even not essential. The real permeability barrier appears to consist of water forming a continuum between the fluids on both sides of the membrane through water-filled conducts inside the membrane. Changes in the physical state of water, POM/EZ-water below threshold, depolarized water (including HF-water) above threshold determine the conductivity and fluxes of ions and many solutes through specific (channels, NKA,...) and non-specific transmembrane conducts (porins, special lipid structures). The boundary of polarized/de-structured water may itself move through the membrane when the threshold is surpassed (as illustrated in the diagram of NKA (figure 4 in part 1 [1])).

It is difficult to determine the location of membrane capacity and of $\Delta\Psi$. In the classical picture and also in the thermodynamic description of Mosgaard et al. [18] the location of the 2 plates of the membrane capacitor is thought to conform to the fixed surface charges of the phospholipids on both sides of the membrane, and $\Delta\Psi$ is thought to be a transmembrane potential. The important physical relationships between a large number of thermodynamical variables as described by Mosgaard et al. apply to the case of a pure (asymmetric)lipid membrane, which nevertheless can produce an action potential almost indistinguishable from a neuronal one without proteins being present. Similar to biological membranes pure lipid membranes are also wet membranes that must be lined with POM/EZ-water. So, an EZ is present that is different on both sides in the case of an asymmetric membrane, and hence there must be different values of potential at the 2 EZ/bulk phase boundaries (a situation quite comparable to biological membranes). Question, however, is: Do these artificial membranes also produce DROS without possessing redox proteins?

The great question in the entire picture is how POM/EZ-water interacts with DROS including the effects of the quantum vacuum (aether), which is the rotating quantum magnetic field forming the omnipresent background of the universe [98,99] that interacts with matter and life. Herein coherent domains (CD's) of polarized water effectuating this interaction possess a quasi-plasma of highly excited electrons making POM/EZ-water a strong electron donor. O_2 is only weakly soluble in POM/EZ-water, but at the EZ/bulk-water interface O_2 might react as a strong electron acceptor with the strong electron-donor (POM/EZ-water), producing DROS which in turn may dissolve preferentially in POM/EZ-water, perhaps executing further structural rearrangements of the

POM/EZ layer (should still be studied). Could DROS with a high oxygen content participate in the formation of molecular structures with a H/O ratio of 1,5 and a higher density than bulk water? Not known yet. Reversibly POM/EZ water is required for some murburn reactions. When executed *in vitro* without enzymes the exergonic radical reaction of $ATP + Pi + DROS (KO_2) (+ \text{crown-ether}) \rightarrow ATP + H_2O + H_2O_2$ needs low water activity. A polarizing template was needed in the form of the added crown-ether. This means that in the absence of POM/EZ-water (A-state) DROS reactivity may slow down or even stop completely. This makes that murburn reactions depend on the cycle of structural changes of water. Water repolarization might mark the onset of ADRS production leading to hyperpolarization. And, how the hyperpolarization due to activated DROS production turns into a stable R-state with associated rest potential? How are the oxidases (and redox complexes) turned OFF when rest potential is reached? If they would continue to produce ADRS, hyperpolarization should remain? And, what happens with the DROS/ADRS remain when rest potential is reached. Are they all used up in murburn reactions, including quenching reactions? There are at present no indications that DROS directly collaborate in the production of POM-water, but this does not mean that they don't.

Reversibly, Voeikov [100] demonstrated that what he calls 'polymer-water' can undergo homolytic splicing, liberating both OH^* and H^* , as evidenced by the production of H_2O_2 (from $OH^* + OH^*$). Once POM/EZ/CD water is formed, it may produce DROS. But to what extent? Rao et al. [101] achieved to ignite (salty) water for a prolonged period of time by irradiating water by irradiating it with polarized 2.45 GHz microwaves and a 13.56 MHz radio-frequency. Given these data, the function of biological redox proteins is rather that of controlled electron injection. But probably this function is combined with control of the state of the protein-associated water, a role that is not yet investigated. Controlling water structure by a protein is not a question of an active center. It is done by subtle changes in the (partial) charge distribution of the protein surface. Such changes may assist in controlling reactivities of the radical cascade of DROS and ADRS. Clearly, a performant diagnostic program to study the (partial) charge distribution of the water exposed parts of proteins and of the Lewis inductive strength of these sites upon the nearby water is needed. (the simple algebraic atomic theory of Kanarev [61] might be a good help. In summary the 'wet' and the 'murburn' aspects of membranes might be tightly connected to each other and together have effect on both ECS and $\Delta\Psi$.

SUPPLEMENT: AETHER PROTOPLASM INTERACTION PROPOSAL

Science proceeds by falsifying wrong ideas. MPT has been a major obstruction for almost a century in the field of cell physiology. In basic physics there are as well some generally 'believed' ideas, which are definitely falsified, nevertheless continue to be instructed. Since (at least) the molecules of living organisms are quantum objects, bio-scientists should know that there are alternatives for the Copenhagen interpretation of the quantum world that obviate the committed errors. They should be adopted as '*best explanation for now*'.

Two crucially important alternatives must be mentioned here. First, Kanarev [61] changed the original Bohr equation for line spectra of electron excitations of only a few isotopes (equation 9) by substituting ionization energy in binding energy (equation 10), something logic because it goes indeed about how strong an electron is bound to its nucleus.

$$\text{Bohr's equation: } E_{\text{photon}} = E_i \cdot [1/n^2 - 1/(n+1)^2] \quad (\text{eq.9})$$

$$\text{Kanarev's equation: } E_{\text{photon}} = E_i \cdot [1/n^2 - 1/(n+1)^2] \quad (\text{eq.10})$$

This change suffices to calculate *all lines of all isotopes* in an algebraic way by applying equation 10. This makes Schrödinger's probabilistic approach and orbital theory entirely superfluous. Electrons do not follow clouds around the nucleus, they consist of a torus turning around its own central axis at a distance from the nucleus, wherein the associated proton is also a torus turning around its own axis. The two axes also coincide with the binding axis (bond axis). In this new atomic model, the hydrogen molecule figures as H·H instead of H:H and the distribution of forces is:

$$p^+ \uparrow \text{ electrostatic } e^- \uparrow \text{ magnetic } e^- \downarrow \text{ electrostatic } p^+ \downarrow$$

In the context of this review this insight simplifies thinking about electron displacements by means of Lewis induction, electron transfers and radicals.

Kanarev made some other corrections in quantum physics, which allowed him to derive a simple toroid model of the photon in a non-probabilistic algebraic and Newtonian way.

A second important algebraic model dealing with other aspects of the quantum world is the '*Aether Physics Model*' (APM) of Thomson and Bourassa [99]. It was developed after they had corrected another mistake in basic physics dealing with the principle of charge. The APM revealed the physical nature of the quantum vacuum or aether. Because: (i) these two important models originated each after correcting some obvious mistakes in the basics, (ii) are exclusively algebraical

(non-probabilistic), (iii) take away much of the weird aspects of traditional '*understanding*' of the quantum world (actually the points which no one understands), and (iv) the two models agree with each other on 8 important conceptual aspects [62], there is no other way for scientific progress than to abandon the wrong aspects of the traditional view, adopt the new proposals in a critical way and test them. Consequences of doing that go deep.

Thomson and Bourassa discovered that there is a fundamental mistake in basic physics with respect to the concept of charge. Because the work of Coulomb revealed that charge is always distributed over a surface, charge should be written in squared form: e^2 instead of 'e' and expressed in coulomb² instead of coulomb. When this is done, the marvel takes place. In an algebraic way this leads to a physical description of the aether, the omnipresent background of the universe, present in the void and present where there is matter. In the latter regions matter (defined as consisting of electrons, protons and neutrons) is *hold* in the half-spin positions of the aether field. The APM also discloses that there are 2 different forms of electrical forces: electrostatic and electromagnetic, acting respectively on two different kinds of charge: electrostatic charge (e^2) and electromagnetic charge (e_{max}^2). These two differ in geometry and quantity: e^2 has spherical geometry and a value of $2.567 \times 10^{-38} \text{coul}^2$, e_{max}^2 has toroidal geometry and a value of $1.400 \times 10^{-37} \text{coul}^2$. They relate according to a fixed ratio:

$$e^2 / e_{\text{max}}^2 = 8\pi\alpha \quad (\text{eq.11})$$

with α the fine structure constant, which differs for electrons, protons and neutrons.

As part of the switch from the cgs-system into the mksA-system (before there were coulombs and statcoulombs) mainstream science has *assumed* that all charge is electrostatic, whereas nearly all charge involving the concepts of potential, current, resistance, magnetic flux, and nearly all basic electron transfer processes are due to magnetic charge. It is at the level of atomic and molecular interactions (see also the model of Kanarev) that electrostatic charge predominates. Thomson and Bourassa could derive the existence of two kinds of charge theoretically and gave experimental proof of it. They also derived that there are two different forces acting respectively on the two kinds of charges. They relate to each other by a constant traditionally considered as a separate force: '*nuclear weak force*'. They demonstrated that the latter is not a proper force, but the ratio between the above 2 forces. So, there remain but 3 fundamental forces: gravitational, electrostatic

and electromagnetic (equal to nuclear strong force), which act at right angles to each other, but exhibit curved force fields. Since they are related to each other by right angles and fixed constants, they can be seen as one fundamental force with different properties spatially distributed according to right angles. Among these different properties are their different extents of application. Gravitation is unimportant at the short distances and small masses of the molecular level, but it predominates for large masses and at long distances, holding the universe together at the large scale. Electrostatic force is important at medium distances including atoms, molecules, organisms and some planetary phenomena. It opposes gravitation between mass and anti-mass, together keeping these two masses in balance at the quantum level up to universe level. (Electro)magnetic (strong) force becomes important at the very short distances of the subatomic world and of radical reactivity.

By developing a '*quantum system of measurement*' with all coefficients equal to 1 (instead of the mksA-system) the quantum world opens its secrets in all simplicity (for instance the unit of 'time' is expressed as 1 quantum frequency, the unit of 'length' as 1 Compton wavelength, etc.). This leads to a simple unified force theory, a dimensional description of the aether, of electrons as identical with quantum angular momentum equal to Planck constant, protons and neutrons identical with their own quantum angular momentum. What is *thought* to be the magnetic momentum of these elementary particles is actually a property of aether in which they reside, which follows from the observation that magnetic momentum is also present in the void). Scrutinizing dimensions step by step lead to the discovery of the physical nature of the quantum vacuum (aether) as that of a giant magnetic field in which the interconnected forces follow curved field-lines, and wherein there are regions called '*aether units*' (A_u) where quantum vortexes occur possessing a high degree of internal coherence. They can hold (but not in the void) different types of '*elementary particles*', the only '*existing things*' in the universe which exhibit long-term stability (required for life and its evolution) because the angular momentum of their hollow torus perfectly fits with the magnetic momentum of the aether unit's half-spin positions according to a simple specific golden ratio relationship. It was derived that aether units define as:

$$A_u = 16\pi^2 \cdot k_c \quad (\text{eq.12})$$

$16\pi^2$ means that aether units have a geometry, that of a double loxodrome, with 4 half-spin positions in which an electron, proton, positron or antiproton can eventually take

seat. In their quantum measuring system Coulomb's constant (k_c) appears as

$$k_c = m_a \lambda_C^3 F_q^2 / 16\pi^2 e_a \quad (\text{eq.13})$$

with m_a = mass of an (empty) aether unit; λ_C = Compton wavelength; F_q = quantum frequency; F_q^2 = quantum resonance, and e_a^2 = electrostatic charge of an aether unit.

The equation of an aether unit can also be written as:

$$A_u = 16\pi^2 \cdot c \cdot Cd \cdot \mu_0 / \epsilon_0 \quad (\text{eq.14})$$

with c = speed of light in vacuum, Cd = conductance of the aether, μ_0 = permeability of vacuum, and ϵ_0 = permittivity of vacuum, the 4 characteristics of the vacuum, multiplied by the geometry of the aether units, $16\pi^2$.

Clearly, the dimensional content of the aether unit conforms to a quantum rotating magnetic field.

All matter including that of organisms is hold in the aether's rotating magnetic field, but not all matter can tap energy from this field. The structural organization of organisms, however, can under certain conditions. King [53] demonstrated that two conditions must be met: the system must be highly non-linear and excited (organisms are, particularly their fourth phase water) and at the same time highly ordered at the quantum level (quasi-plasma of electrons in fourth phase water; according to Fröhlich vibrating at a single common frequency, a measure of order in a liquid [76,77]). Since highly excited water forms a continuum between the external EZ, the water inside membranes and water in the interior of a cellular compartment separated by a membrane, i.e., forming a continuum throughout the whole protoplasm (or during A-state part of it) [1,78], a direct energetic and informational connection between the '*material protoplasm*' and the all-permeating rotating magnetic background field of the universe exists. If during a local A-state some POM/EZ-water is depolarized/de-structured the connection is lost, then that protoplasmic material must survive and the material protoplasm must survive from the properties of its elementary particles, which are still individually hold in some half-spin positions of the aether, but individually are no more excited and as a group no longer ordered so that energy and information tapping does no longer takes place. For the situation that there is connection, one should remember that the higher the frequency (quantum fluctuations have the highest frequency known), the more information can be stored. (Does inspiration conform to messages from the vacuum transmitted during connection? Inspiration and thinking are two different phenomena; and inspiration comes when the brain is relaxed.) After action the connection can be reinstalled with metabolic energy input from murburn processes whereby thanks to

1-electron injections POM/EZ water can be reinstalled (see the mechanism explained in the conclusion).

In the context of protoplasm connected to the aether-field, Thomson wrote me that biologists are missing the key units and equations to describe life because the applied system of units is faulty. It should be realized that MRI reveals information about the *conductance* of the body (equation 14 gives the relation with the aether units). The interpretation given here is that MRI images give topological information about the degree of energetic and informational connection of the material body with the aether, where the informational content is much higher. Thomson wrote: *“Instead of the body having a network of electrical cables, it has a network of tissues that varies in conductance. The conductance is directly influenced not only by the electrochemical processes, but also by feelings, and feelings are directly measured by conductance. So, there is a mind-body connection in the biological sciences.”*

OLD WISDOM

In the view of the Ancient the body consists of earth, water, air and fire. Since the discoveries of Manoj, the old view becomes comprehensible. After incinerating a body the mineral ashes remain (earth). The body contains water and O₂ and CO₂ are involved in the murburn systems of respiration and photosynthesis. The fire is linked with murburn combustion via DROS reactivity and with the quasi-plasma of excited electrons of POM/EZ water. It appears that the old terms also correspond to the 4 aggregation states of matter: solid, liquid, gaseous and plasma.

Another old wisdom, which now revives in popular literature tells that different bodies can be discerned: the one that is best observed is often called the *‘physical body’*. Other bodies are the energetic body, the mental body, emotional body, astral body, aether body and spiritual bodies. The classification is not always the same and that can be confusing. Here it can be said that speaking about the *‘physical body’* is a misnomer. Because in scientific terms some of the other bodies – at least the mental body, likely the emotional body, and the biophoton and longer wavelength electric field aspects of the energetic body – may consist of electromagnetic holograms, which are physical too. Therefore one should change the term *‘physical body’* into *‘material body’*. Since the development of the aether physics model, it became clear what the *‘aether body’* is (but one should read the work of Thomson and Bourassa to come to an understanding). It is the background rotating magnetic field that holds the material body and conveys the

bodies consisting of electromagnetic holograms. Physics can now start to describe all these bodies in physical terms. Is there a level below the aether? If there is, it would be the realm of spiritual phenomena such as love/Love.

Conflicts of interest: The author declares no conflict of interest.

Funding: The author received no funding, governmental or private, for this work.

Ethics: The article is a review and has no experimental section.

Orcid: 0000-0003-0778-5798

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