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Biologically Structured Water-A Review (Part 2): Redox Biology, Plant Resilience, SW Drinking Water Types, BSW Water and Aging, BSW Water and Immunity

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Abstract:

A review was conducted between redox biology and BSW water to link their interactions with cell bioenergetics. The exchange of electrons and protons from energized BSW water significantly contributes to recycling energy biomolecules during aerobic respiration. Plant resilience to biotic and abiotic stressors is also significantly improved by maintaining adequate levels of BSW water. The physicochemical properties of SW water are readily measured and are associated with improved human health. Natural healing water and SW water products have similar physicochemical properties. Medical literature shows a direct association between dehydration and age-related diseases. Drinking SW water enhances rehydration rates and increases intracellular water content. Research has also suggested that drinking SW water has a positive effect on certain neurological diseases and cancer types. Finally, drinking SW water improves the immunity system in humans.

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1. BSW WATER AND REDOX BIOLOGY

As Part 1 of this review mentions, BSW water has unparalleled prominence in biological redox reactions. The eminent redox properties of BSW water are due to the cold vortices of quasi-free electrons and protons within the interfacial structured water zone. The TEM images by Cardarella [1] of CD spheres show that the surfaces of the spheres were electron-dense, indicating that the spheres had cold vortex shells of quasi-free electrons (see Figure **1** in Part 1). These sub-atomic particles are donated and received for ultra-fast redox reactions to ensure redox homeostasis [1-9]. Electrons serve several functions, such as signaling particles, quenching of free radicals, or even combustion of O_2 by transferring single electrons that result in H_2O as the final product.

Redox biology is associated with cell membrane potential. Red and infrared light increases mitochondria membrane potential, increasing the energy and redox potential on mitochondrial membranes [17-20]. When the gain of electrons reduces NAD^+, $NADP^+$, and ADP, they are recycled back to NADH, NADPH, and ATP [9-11]. These biomolecules are critical in mitochondria pathways, calcium homeostasis, antioxidation, gene expression, immunological functions, aging, and cell death [9-11]. NADPH is a substrate for NADPH oxidase, which contributes to ROS signaling and hydrogen peroxide generation, which may be used to inactivate pathogens. When NAD^+ is reduced by receiving an electron, it recycles back to NADH, and the $NADH/NAD^+$ ratio increases. This $NADH/NAD^+$ ratio is a key biomarker for many critical cellular functions, including metabolic pathways, DNA repair, chromatin remodeling, cellular senescence, and immune cell function [9-15].

Unfortunately, the ability to maintain robust redox homeostasis with mitochondrial energy biomolecules declines with age [13-19]. Recent aging reviews reveal a causal link between declining NAD^+ levels and increased risk in age-related diseases, including cognitive decline, cancer, metabolic disease, sarcopenia, and frailty [13]. Aging studies have shown that NAD^+ is a vital cofactor/coenzyme and a signaling messenger that can modulate cell metabolic and transcriptional responses. Studies have shown that sirtuins are NAD^+ dependent enzymes, and the availability of NAD+ regulates their activities. Sirtuins are essential enzymes in delaying cellular senescence, or the formation of ‘zombie cells,” and extending longevity or lifespans. In summary, dysfunctional mitochondria lead to increased oxidative reactions, a decline in robust redox homeostasis, and an increase in age-related disorders [13-19]. Numerous review articles suggest alternative precursor supplements to increase NAD levels or reduce ROS damage to mitochondria to extend human longevity. An alternative therapy to extend longevity that is seldom mentioned in health or aging journals is to increase BSW water levels by either replenishment by drinking SW water or exposure to red and infrared lamps to increase BSW levels with *in vivo* treatments. Both therapies will be explored further in the following sections of this review.

A study by Sohal *et al*. [20] studies the effects of redox dynamics on house fly longevity. They found that the $NADH/NAD^+$ ratio decreased from 1.1 to 0.43 when flies reached 16 days old and reached 20% mortality. The decline in the ratio shows an oxidizing trend for NADH across the lifespan of flies. Also, there was a strong trend for H_2O_2 to increase across the lifespan of flies. Another house fly study by Farmer *et al*. [21] reveals that house flies with an increased rate of O_2^- production had shorter life spans. They state that as oxidative stress from ROS radical injury increased with age, the longevity of house flies decreased. These studies reinforce that maintaining redox homeostasis as aging occurs is critical to increasing longevity. Part 2 of this review series offers suggestions on maintaining BSW water levels as humans age, ensuring a ready supply of quasi-free electrons and protons for all redox reactions, and preserving redox health.

2. BSW WATER AND PLANT RESILIENCE TO ABIOTIC STRESSORS

Photosynthesis and BSW water are linked in a complex set of relationships. The first reaction in photosynthesis's light phase is splitting water to initiate the Electron Transfer Chain. In plant chlorophyll, Photosystem II splits water into protons (H^+), electrons (e^-), and molecular oxygen (O_2).

$$2H_2O + h\nu \rightarrow O2 + 4H+_{\text{lumen}} + 4e^-$$

Recent research on PSII water splitting reveals that proton channels transport H^+ from the water splitting site in PSII. Also, aquaporin channels supply PSII with water molecules [22-28]. This research shows that the proton wires, or channels, contain BSW water molecules constrained or restricted by electrostatic bonds to transport protons along delocalized H-bonds [22-28]. In addition, as BSW water levels increase, free protons (H^+) with symmetric double-well energy profiles can join with H_2O to form hydronium ions (H_30^+), a carrier for H^+ [31]. Protons generated from splitting water can be removed by proton water wires or converted into hydronium ions in the presence of BSW water. Plant research also shows aquaporins supply BSW water to PSII for water splitting. However, aquaporins do not restrict water movement, so water can be transported into the PSII subunit without transporting protons simultaneously [22-28]. This research shows that BSW water, or strong H-bonded water, is crucial for PSII water-splitting activities.

Hussein *et al*. [28] investigated the water structure in PSII water channels. They state that water molecules along the aquaporin water channels are highly structured [28]. A study by Doyle *et al*. [29] also investigated water structure in PSII subsystems. They state that the Oxygen-Evolving Complex (OEC), or the water-splitting complex within PSII, contains crystallographic or crystal water. They also state that the Molecular Dynamic (MD) computer simulation shows a "higher electron density in the channel regions compared to waters in bulk, which indicates that the water structure is more ordered within the channels" [29]. The high electron density MD simulation estimates agree with the TEM images of SW water [30] mentioned in Section 1 of Part 1. SW water has delocalized electrons that circle the pentamer or hexamer water rings. This electron cloud that forms the outer shell of water spheres is electron-dense, indicating that PSII subunits contain BSW water with crystalline structures [30]. As previously mentioned in Part 1. BSW water is energized and only requires low energy input of red light to ionize water or split water without relying on high energy light frequencies that would injure chlorophyll tissue [31].

A study by Gauthier *et al*. [32] estimated that PSII subunits can generate up to 30 µmol O_2/sq m/s by splitting H_2O when exposed to a light intensity of 1,000 µmol PAR/sq m/s in French bean (*Phaseolus vulgaris*) plants. Their study shows that PSII water splitting under high-light intensity requires many water molecules (up to 3.61×10^{19} H_2O/sqm/s) to generate the 30 µmol O_2/sq m/s in French bean plants. This estimate of water molecules is based on the fact that 12 H_2O molecules are required to be split to generate 6 O_2 molecules. The PSII research estimates that the aquaporins can supply this flux rate of water molecules. However, under full sunlight with high PAR values, the supply of BSW water could be rate-limited, thereby reducing water splitting rates and initiating photoinhibition to protect PSII from excess free radical damage.

As mentioned above, magnetic fields increase SW water levels depending on static magnetic strength and exposure time [33-36]. Tu *et al*. [37] investigated the effect of magnetic fields on oxygen (O_2) production in an algal-bacterium symbiotic complex in a wastewater treatment study. They found a 24.6% increase in O_2 production when the algal-bacterium complex was exposed to a static magnetic field of 100 mT. Yang *et al*. [38] also investigated the effect of magnetic fields on *Chlorella vulgaris* on O2 production. They found that O_2 production increased by about 100% after two h exposure to a static magnet field (250 mT). These studies indicate that static magnetic fields increased SW water in the culture solution, increasing the rate of water splitting in the bacteria PSII subsystem with a subsequent increase in O_2 production. These bacteria studies provide indirect evidence that increased levels of BSW water within chlorophyll optimize PSII water splitting rates. In other words, any rate-limiting restrictions due to a limited supply of energized BSW water in excess nutrient solutions are overcome by magnetic fields that increase SW water levels in the solution.

The terms tightly bound water and BSW interfacial water are synonymous in crop research involving drought tolerance. These terms refer to the strongly bound, interfacial water layer covering cell membranes or about 60-70% of the intracellular water content in plant tissue. Bound water in plant tissue is generally estimated using an instrument that measures water activity. These instruments measure free water in plant tissue in a sealed, temperature-controlled chamber [39]. As the free water evaporates in plant tissue and reaches equilibrium with the air vapor, the relative humidity of the air in the chamber is measured to estimate the water activity value. The amount of bound water can be estimated by subtracting the free water content from the total water content of the plant tissue.

Another method of measuring BSW water in plant tissue is Differential Scanning Calorimetry (DSC) [40]. This calorimeter method measures the temperature and heat flow associated with a material based on glass transition temperature values [41]. A stepwise change in the heat flow indicates when plant tissue's interfacial or intracellular water transitions from a liquid state to a "glassy state" [41]. When plant tissue water content is reduced to 0.1 g H_2O dry weight, the tissue enters a "glassy state" [41]. BSW water had liquid crystalline properties, while a glassy state in plant cell cytoplasm has an amorphous mixture of biomolecules and water with extremely high viscosity.

The glass transition temperature marks the threshold when the rubbery stage in plant cytoplasm transforms into the glassy stage, and all the free water has been vaporized [42]. Kunzek *et al*. [43] found that the viscosity of glassy state water in plant tissue can reach 1,013 Pa s. This level of extreme dehydration can only be achieved by high temperature drying in ovens. When the intracellular water content is reduced from about 0.5 to 0.1 0.1 g H2O/g tissue, the plant tissue is beyond rehydration and revival, even for desiccation-resistant plant species. The glass transition temperature (Tg) can be used as a biomarker to compare drought and desiccation tolerance in plant and crop species [44-45]. Exothermic peaks in the DSC data may indicate the degree of crystallization of the test material [46]. DSC software is programmable to test for Tg values in plant material. Given the assumption that BSW levels in plant foliage are correlated with drought tolerance, DSC tests for water properties in foliage would provide valuable insight into drought tolerance testing of crop varieties.

Numerous articles have correlated bound water levels in plants with increased drought tolerance [47-48]. Rascio *et al*. [47] investigated two wheat genotypes (*Triticum durum*) grown under water stress conditions. The first wheat genotype had a regular cell affinity for bound water or BSW water, and the second wheat genotype was a mutant genotype with a higher affinity for bound water. They found that the mutant wheat genotype with higher levels of bound, or BSW water, had significantly lower leaf temperature than the non-mutant genotype even as the air temperature increased to 35 C. They also found that the mutant genotype had about 66% lower transpiration rates than the non-mutant genotype. Another genotype study by Rascio *et al*. [48] found that the drought-tolerant wheat genotype had a higher level of bound water in the wheat foliage.

Drought tolerance studies involving cotton by Ergashovich *et al*. [50] and Singh *et al*. [51] show a correlation between bound water levels in the foliage and increased tolerance to water stress. Jecmenica *et al*. [52] found that bound water in common bean foliage increased root length when bean plants were grown at 30 C. Zhang *et al*. [53] found that the ratio of bound water to free water increased in water-stressed sugar cane that had a foliage chemical treatment. Wang *et al*. [54] studied the effects of hot, dry summers on a drought resistant C4 tussock grass (*Heteropogon contortus*) used for grazing in China. They found that the bound water to free water ratio (BW: FW ratio) was the most sensitive parameter for measuring water stress sensitivity. Also, they found that the BW: FW ratio was 152% higher in the drought-resistant tussock grass grown at 4 % soil moisture compared to the control treatment grown at 10%. An ecological study by Yukui *et al*. [55] found that the BW: FW ratio was correlated with drought resistance in desert shrubs. Other studies show more indirect findings involving correlations between bound water in plants and their ability to increase drought tolerance or resistance. It is evident from this literature that the ability of a plant genotype or species to increase its BSW water levels also increases its drought tolerance and ability to minimize environmental abiotic stressors such as water stress.

Several reviews were published on the effects of watering plants with structured water [56-58]. However, very few studies have measured the properties of their structured water and the crop responses to their SW water treatments. A deficit irrigation study by Ramsey [59] investigated the effects of magnetized seeds and SW irrigation water on velvet beans (*Mucuna pruriens*) grown under water stress or reduced irrigation conditions. A complete description of the study methods and plant responses is described in Ramsey [59]. The combined effect of magnetized seeds and watering with SW water minimized kidney bean plant water stress levels based on the gas exchange responses. Also, the combined treatments resulted in a water saving of 29 to 49% for the optimum treatments. Correlation analysis among the gas exchange and soil moisture data revealed several plant responses were unlinked from their typical responses to increased water stress conditions for the optimum treatments.

In the two years following the publication of this article by Ramsey [59], a more in-depth data analysis revealed new findings to explain these improvements in drought tolerance due to the combined treatments. The data was reanalyzed to correlate unexplored gas exchange responses with the magnetized seed and SW irrigation water treatments (see this article in this special issue). The new findings show that the magnetized seed and SW water treatments altered foliage water properties and deactivated a large suite of plant defense responses intended to minimize plant injury to intense water stress conditions. Crop irrigation with SW water and magnetized seed treatments is time-consuming and increases crop input costs. However, if irrigation water savings could approach even 30 or 40%, the additional input expenses may be cost-effective enough to evaluate in farm-scale studies. This study also indicates that plants are quantum coherent due to their ability to deactivate many critical plant defense activities in spite of soil moisture reaching about 2% (v/v) for the optimal seed and water treatment under the high water stress treatment. Despite the low soil moisture, the optimal treatment had an average daily water saving of about 50% that started about 30 days after planting into the 60-day study.

3. PHYSICOCHEMICAL PROPERTIES OF STRUCTURED WATER

There are many polymeric water structures and maybe hundreds of supramolecular water structures [30]. Analyzing the structure of water is a difficult task. However, SW water can be indirectly quantified and qualified by its water properties. Measuring the physicochemical properties of SW water is an inexpensive method of quantifying proton concentrations and potential for electron exchange rates. SW water's physicochemical properties differ from tap water, indicating the potential functional properties when SW water is converted into BSW water. Three physicochemical water properties are readily measured and are directly related to the ability of SW water to exchange electrons and protons in redox reactions. These properties are pH, oxidation-reduction potential (ORP), and electrical conductivity (EC), which directly or indirectly measure the concentrations of protons (H^+) or electron potential (e^-) in a water sample.

The concentration of H^+ in an aqueous solution is measured as the-log[H^+], otherwise known as pH [22-23]. When the covalent bonds for H_2O are broken, then H^+ or OH^- are the common ionic forms resulting from the half-reactions that form the basis for all biological acid-base reactions. The relative concentration of H^+, or hydronium ion (H_3O^+) in solutions, supports much of the cell's needs for proton signaling and recycling of several biomolecules back to their non-reduced state. As mentioned in Part 1, as water becomes more structured, some protons have low energy barriers and, with negligible energy inputs, can join with H_2O to form hydronium ions (H_30^+). In addition, hydronium ions are excluded from the EZ water zone, increasing membrane potential and the energy levels available for cells. Also, hydronium ions resonate at 7.85 Hz, increasing the EZ water level on cell membranes. These findings show that increasing the pH levels within physiological limits also increases cell membrane potential and the EZ water zone in living organisms.

The status of electron concentration in an aqueous solution or cells is measured as the oxidation-reduction potential (ORP). A simple definition for ORP is a solution's capacity for electron transfer. ORP is an indicator of the oxidation-reduction status based on the collective electron activity within the solution [60-64]. Meters measure ORP as the voltage potential reading between the measuring and reference electrodes. A positive ORP indicates the ability to accept electrons as an oxidizing agent. A negative ORP indicates the ability to donate electrons as a reducing agent. Depending on the solution being measured, the ORP electrodes will serve as either an electron donor or an electron acceptor. Redox reactions that generate a negatively charged ion could include a wide range of molecules; thus, it is impossible to identify all the ionic species contributing to a cell's collective electron-based redox conditions. Because the ion species are difficult to identify in solution, ORP measures the collective electron concentration measured by electron flux or ORP in millivolts (mV), a numerical index of the intensity of oxidizing or reducing conditions within a system [60-64].

Most mineral and municipal tap water sources have a positive ORP of + 200 to + 400 mV (Table **1**). The water sources in Table **1** also have a wide range of ORP values, indicating that humans can tolerate a wide range of ORP values, including negative and positive values, without any harmful health effects. Most drinking water sources have a positive ORP with pro-oxidant properties, i.e., the water receives electrons. In contrast, BSW water has a negative ORP; thus, the water can donate electrons and has tremendous antioxidant properties due to the ubiquitous presence of water in cells [65].

The scales for ORP and pH are similar in that they both have a neutral center point with negative and positive readings extending from the center point. The physiological range for pH in humans is tightly controlled, with a narrow range between 7.35 to 7.45. The physiological range for ORP is much higher, including + 150 mV in the stomach,-110 mV in the throat, and-250 mV in the large intestine [59]. Typical ORP values for cells range from approximately -10 to -90 mV, depending on the cell type [60-61].

Table 1: Typical Oxidation Reduction Potential (ORP) Values for Liquids, Drinking Water, or Biological Tissue for both Negative and Positive ORP Ranges [65]

Aqueous liquid	Redox potential (negative mV)	Aqueous liquid	Redox potential (positive mV)
Organic-rich saline	-400	Degassed pure water	+200
Euxinic water (H_2S)	-250	Distilled water	+250
Healthy human cells	-170 ~ -290	Groundwater	+250
Anaerobic yeast fermentation	-180	Mineral water	+200 ~ +400
Green tea	-100	Tap water	+220 ~ +380
Vegetable juice	-70	Surface seawater	≈ +400
Mother's milk	-70	Swimming pool	+400 ~ +475
Ave. human environment	-70	Rainwater	+600

Research was conducted on physicochemical water properties during the generation of SW water (Ramsey unpublished data). The physicochemical data shows a negative, linear relationship between ORP and pH (Figure **1**). The regression equation in Figure **1** shows that a pH of 9.0 has an ORP value of -89 mV. This is a loose relationship because pH and ORP varies when measured in water samples with widely different properties. Also, the negative relationship shows that the concentration of hydroxide ions (OH^-) or alkalinity of water and negative electron activity (negative ORP) are directly related to one another. This relationship also has implications for SW drinking water and overall health status and resilience to environmental stressors.

ORP is generally buffered in plants and animals to meet the cell type or organ functional needs. While pH value can be measured within seconds, a stable ORP measurement can take up to several minutes, if not hours, to reach a stable value due to the type of reactions and their reaction rates. The ORP measurement is strongly influenced by metal surfaces and the cleanness of the electrode [61-62, 64]. Structured drinking water studies have not yet evaluated whether drinking water with high negative ORP values (> -250 mV) may be buffered as absorbed into the body, minimizing any potential health benefits of lowering overall ORP levels. Numerous drinking water studies, however, have correlated the physicochemical properties of structured water with any health effects [65-73]. The physicochemical properties of different water types or sources are listed in Tables **2**, **3**, and **4**.

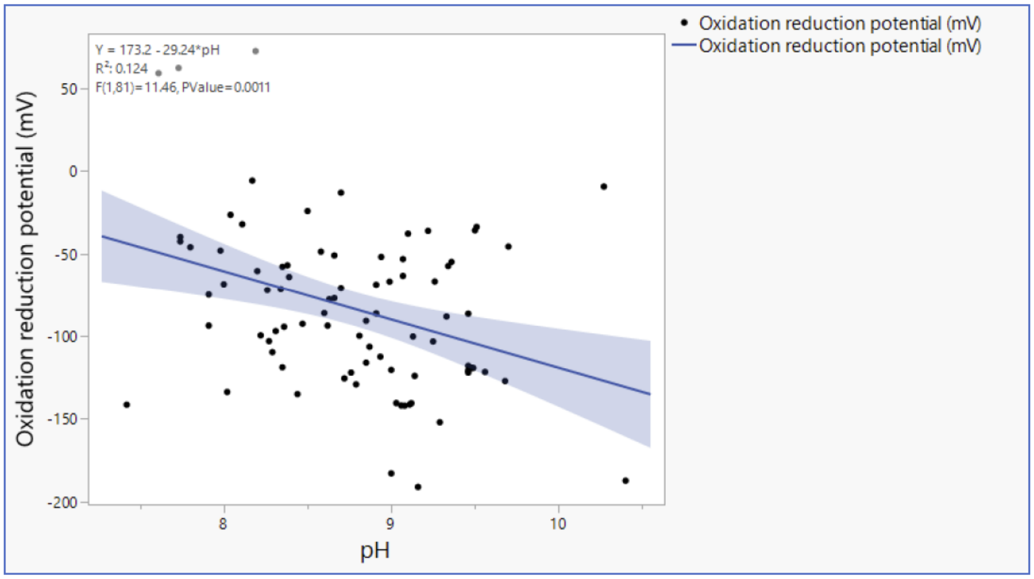

Figure 1: Linear regression between ORP and pH for custom-generated SW water (unpublished data).

Table 2: Comparison of Physicochemical Water Properties between Seawater and Several Types of Drinking Water. The Drinking Water Samples were Measured for the Four Water Properties by this Author

Water Description	Electrical Conductivity (uS/cm)	Oxidation Reduction Potential (mV)	pH	Total dissolved solids (ppm)
Sea water	50,000	+450	7.9	-
Charcoal Filtered tap water	397-418	-70 to-71	8.0-8.2	202-209
Unfiltered tap water	301.7	-76.6	8.315	-
Distilled water	4.22	-59.6	8.22	2.13
Mineral water	378.5	-178.0	8.33	189
Filtered bottled water	192	-136.1	6.42	96.1
Reverse osmosis water	69.7	-94	7.0	22
Commercial alkaline drinking water	195.7	+33.2	9.27	97.82

[a] Average value for surface seawater.
[b] Commercial water from the Colorado aquifer.
[c] Water generated from electrolysis using the cathode probe to collect alkaline water.

Table 3: Comparison of Physicochemical Water Properties between Structured Water Samples and Natural Springs, Wells, or Rivers known for Healing Powers or Promoting Good Health

Water Description	Electrical conductivity (uS/cm)	Oxidation Reduction Potential (mV)	pH	Total dissolved solids (ppm)
Commercial structured water	860	+106.4	7.8-8.2	34
Custom Generated Structured Water-concentrated	8,000-10,000	-24	8-9	205
Custom Generated Structured Water - diluted	872-1,000	-13	7-8	697
Brandholz at Nordenau slate cave water[b]	Na	-250	8.01	Na
Water from Hunza river[c]	30.37 to 113.5 for river samples	-50 to -450	8.32 to 7.13 for river samples	22.61
Zamzam natural well water[d]	976-1390	Na	7.73	798-1000

[a] https://kaqun.hu/.
[b] Henry M, Chambron J. Physico-chemical, biological and therapeutic characteristics of electrolyzed reduced alkaline water (ERAW). Water. 2013 Dec;5(4):2094-115.
[c] Ali A. Hussain Z. Khan Z. Hussain A. An Assessment of Physico-Chemical and Microbiological Parameters of Water from Hunza and Gilgit Rivers, Gilgit-Baltistan Pakistan 2015 (www.jcbsc.org).
[d] Abdullatif BM, Baeshen AA. Assessment of Different Water supplies in Jeddah as an indicator of water quality and their impact on seed germination. Life Science Journal. 2013 Jan 1;1:10.

Table 4: Water Properties for Structured and Unstructured Tap Water

Water Property	Structured water	Unstructured tap water
Density (g/ml)	0.97	1.0
Specific heat (cal/mol)	1.25 (18-20 cal/mol)	1.0 (15-18 cal/mol)
Viscosity (mPa.s at 25 C)	2-10 times tap water	0.89
H-bond energy (kcal/mol)[a]	24	2.4 to 12 (ave. 5.6)

[a] Mandumpal JB. A Journey Through Water: A Scientific Exploration of The Most Anomalous Liquid on Earth. Bentham Science Publishers; 2017 Mar 1.

4. EFFECTS OF DRINKING SW WATER ON HEALTH AND LONGEVITY

The human body has an average water volume of 3.71 l and 2.71 for males and females, respectively [74]. A concept article by Messori *et al*. [75] estimates that the percentage of BSW interfacial water in a human adult ranges from 20 to 30%. Based on these two water volume estimates, the average volume of BSW interfacial water would range from 740 to 1,110 ml for males and 542 to 813 ml for females in humans, or about 2.47 to 3.71 x 10^{25} and 1.81 to 2.72 x 10^{25} molecules of SW water in males and females, respectively. Other estimates of extracellular (ECW) and intracellular water (ICW) state that the average adult human should have an ICW: ECW ratio of about 75% ICW and 25% ECW water content [76-79]. Shi *et al*. [80] conducted a Raman microscopic study of BSW water in HeLa cells, revealing that BSW water was 64% of the total water in the cytoplasm of a human cell, and the other 36% was free water, i.e., ICW water consists of 64% BSW and 36% free water. These estimates for ECW and ICW water content in humans indicate the importance of BSW water, whether covering cell membranes (ECW water) or inside cells (ICW water). Guo *et al*. [81] investigated the heat of vaporization of bound water using NMR and DSC methods in radiata pine tissue. They found that 30% of the total water content in the wood tissue was bound water.

Several health studies involving hydration, human longevity, and age-related diseases have concluded that “free biological water” decreases with age [22, 82-84]. As dehydration accelerates during aging, it becomes critical to replenish BSW water levels for everyone over 50 or 60 years old [85-88]. One review on aging and dehydration states that the total water content in a 45-year-old adult ranges from 65-70 %, which decreases to about 45-50% in a 70-year-old man [89]. Another dehydration review by Lavizzo-Mourey [90] states that the total percent body water decreases to 50.8 percent in men aged 61 to 74 years and to 43.4 percent in women aged 61 to 74 years. A third dehydration review by Hooper *et al*. [91] states that the percentage of body water content decreases from 70 to 60 to 50%, respectively, in newborn babies, childhood, and older adults. These human dehydration reviews generally agree about a 10 to 20% loss in water content as young adults mature into their sixties and seventies. An abundance of medical literature has shown that even a conservative loss of 10 to 15% water content due to aging has proven to be strongly correlated to many age-related diseases [85-87]. No medical research has yet evaluated the effects of SW drinking water on age-related diseases. However, a few water drinking studies have shown that SW water is associated with human longevity and that rehydration at the cell level can be enhanced.

The challenge of water replenishment therapy is whether drinking non-structured or structured water enhances BSW water levels. The drinking water market offers so many confusing claims for improving health status that a review of the clinical evidence is needed to distinguish which water products work best for enhancing BSW water levels. Drinking water products can generally be separated into water products with various compositions, such as alkaline or H2-infused water and structured water products. Alkaline drinking water is treated with minerals or electrolysis to raise the pH of the water. These water products increase the water's hydroxide ion concentration or alkalinity. A recent venture in changing water composition is infusing hydrogen gas (H_2) into the water. The claims for hydrogen water include antioxidant properties with increased energy and longevity and improved muscle recovery after a workout [92]. As mentioned above, increasing the pH level within physiological limits, which is 7.35 to 7.45 in humans, also increases cell membrane potential and BSW water levels. Therefore, alkaline water and H_2-infused water products can slightly raise blood pH levels and increase cell energy levels.

A hydrogen water study by Matsiyevska [93] reveals that H_2 gas changes physicochemical water properties, modifying human blood parameters. His findings state that human blood varies in ORP from -100 to -200 mV. Also, his study found that mineral water treated with H_2 gas reduced the ORP to -103 mV, with a pH of 6.84 and rh of 16.9 for the mineral water. When they infused H_2 gas into tap water, the ORP was -210 mV, with a pH of 7.4. These physicochemical water properties do not match the linear regression results in Figure **1**, i.e., water with an ORP of -130 mV should have a higher pH. Generally, H2-infused water products on the market have a pH ≥ 9. The addition of H_2 gas in mineral water results in hydronium and hydroxide ions, resulting in a significant reduction in ORP. The subjects that drank the hydrogen-saturated mineral water had oxygen-rich blood, and all the white and red blood cells returned to normal shape. Their findings show that H_2-saturated water reversed age-related blood cell aggregation and excess clotting, and the blood parameters were close to ideal [93].

More recent drinking water studies with H_2-infused water reveal the effects on blood pH. Ostojic [94] found that blood pH increased by ~6% in adult men who drank two l/day of H2-infused water for seven days. Another study by Ostojic *et al*. [94] found that blood pH increased by 0.04 (negative log H^+) for men who drank two l/day of H_2-infused water for 14 days. Drid *et al*.

[95] found that female athletes' blood pH raised from 7.39 to 7.47 after drinking 300 ml of H_2-infused water. As previously mentioned, increasing pH increases hydronium ions (H_3O^+), increasing cell energy levels. These drinking water studies provide real world evidence that drinking water with enhanced physicochemical properties can alter blood properties and ultimately improve overall health. The advantage of drinking SW water properties is that the water is already structured and has alkaline properties with a pH range from 8 to 10.

A website for a commercial hydrogen water product [97] reports that electrolysis is used to generate drinking water with an ORP of -850 mV. Drinking water with a negative ORP has reductive properties, and as the absolute value of ORP increases, the reductive or antioxidant properties increase [97]. BSW interfacial water always has a negative ORP value (Table **1**). Any drinking water products with reductive properties or a negative ORP have inherent antioxidant properties that match the cell membrane potential's negative redox properties.

Currently, there are no published drinking water studies involving structured water and its effects on age-related diseases. However, a few water drinking studies have shown that structured water is associated with human longevity, and rehydration at the cell level can be enhanced [97-111]. Two drinking studies with human subjects showed that intracellular water content improved after drinking different forms of structured water. Fisher *et al*. [98] evaluated the effects of drinking structured water (0.5 l/person) using an MRET water generator that adds structure with a resonance device oscillating at 7.8 Hz. Using a bioimpedance meter, they found a 4.2% increase in intracellular water. They state that the ratio of extracellular to intracellular water in humans is approximately 20:40 and that an average 75 kg male has a total water volume of 45 l with 30 l of intracellular water. A drinking water study by Smirnov [99] also evaluated the effects of MRET-structured water and found that intracellular water uptake increased three-fold. A third drinking water study by Johansson and Sukhotskya [100] found that structured water improved the resiliency and auto-stabilization of human heart rates within 15 min. of drinking 100 ml of water.

Replenishing BSW water with drinking SW water or using infrared lamp treatments to increase EZ water "*in vivo*" can improve neurological health. A case study by Smirnov [101] found that a man suffering from cerebral palsy had exceptional recovery after drinking SW water for twelve months. The MRET water generator was also used in this case study. In another study, Smirnov [102] tested the MRET water generator on transgenic mice that expressed an amyloid gene that increased amyloid plaque production. The brain area in the mice that drank the MRET water increased their total brain area by 15% compared with the control mice. Also, the transgenic mice predisposed to amyloid plague production that drank tap water had a mortality rate of 33%, which is comparable to the 25 to 40% mortality expected from this type of transgenic mice. In comparison, the transgenic mice that drank the MRET water had a mortality rate of 9% or a 75% decrease in mortality due to drinking the MRET water.

Another independent study by Saltmarche *et al*. [112] indirectly validated the transgenic mouse study by Smirnov. The Saltmarche study tested mild to moderately severe dementia or Alzheimer's patients with a near-infrared (NIR) photo-biomodulation light attached to their heads with a 41 mW/cm^2 power density. The use of infrared pulsed radiation in these patients also increased the EZ water zone in their brain tissue, as Chai *et al*. [113] found that far-infrared light increased the EZ water zone to 600 µm after just 10 min. Exposure. The NIR treatment used in the Saltmarche study likely increased the BSW water levels in the patients' brains over the 12-week study. The patients had significantly improved test scores and personality profiles after 12 weeks of NIR brain treatments. In addition, the study results were comparable to those from a large dementia study that tested a dementia drug (donepezil). In other words, the NIR study improved the neurological health of dementia patients and had comparable results to a dementia drug study. Other clinical studies that tested NIR photo-biomodulation treatments on dementia and Alzheimer's patients found similar improvements in neurological recovery [114-116]. These research findings with either MRET water generator or NIR lamp treatments provide evidence that increasing BSW levels in transgenic mice or dementia patients can improve longevity and increase neurological recovery rates.

A study by Wang *et al*. [117] evaluated "micro-clustered water (MC)," or structured drinking water, on the hydration status in humans. They found that diabetes patients who drank micro-clustered water had improved cell water distribution (ICW/ECW), basal metabolism rate (BMR), phase angle (PA), and cell capacitance

(CP) during the four-week study. Liguori *et al*. [118] investigated the effects of Ion Cyclotron Resonance (ICR) treatments in a human clinical trial (See Part 1 Section 3). The ICR treatment included the Schumann Resonance (7.88 Hz), hydronium ion (H_3O^+) resonance, and several mineral ion frequencies in sequential wavelength treatments. They found that the intracellular water content, based on bio-impedance meter readings, increased for the ICR treatment. In addition, the ICR treatment increased the IWC water structure, indicating that ICR treatments increase BSW levels in humans [118].

An unpublished study by Jhon [110] investigated the effects of SW water on the longevity of beagle dogs. The study evaluated the survival rate for 32 beagle dogs for over a decade-long test. The study showed that more than half of the dogs that drank SW water survived over 13 years. However, half of the beagles that drank the unstructured water survived less than seven years [110].

Magnetized water research has the most extended history and the most published studies. However, few drinking water articles have published any details related to SW water properties. Research on the effects of magnetic fields on water properties reveals that bulk water becomes more structured depending on the strength and duration of the magnetic fields [119-124]. The health benefits of drinking magnetized water have been widely researched [125-133]. The evidence is compelling that magnetized drinking water improves animal health, but the same literature offers few links between magnetized water and SW water properties.

Many case studies investigated the effects of drinking natural water with SW properties that have increased health and longevity [134-140]. Over a dozen research and case studies by Ignatov evaluated the effects of SW properties of natural water sources on human health and longevity have been published [141-150]. He measured the physicochemical water properties from high-elevation streams (1,000 to 1,500 m) in Bulgaria in a region containing shungite minerals and zeolite clays [144-145]. Shungite is an ancient rock containing non-crystallized fullerene-like carbon (30 %), silica (45 %), and silicate mica (about 20 %). Shungite alters physicochemical water properties such as oxidation-reduction processes, sorption, catalytic, biological activity, and electrical conductivity, improving its health benefits as a drinking water [144-145]. Ignatov used the evaporation angle of water droplets to estimate the energy of hydrogen bonds of shungite and zeolite solutions in water [141-150]. He found a significant relationship between the H-bond energy of the mountain drinking water and extended life spans for the villagers drinking the mountain water. Ignatov states that the average number of centenarians in Russia and Bulgaria is 8 and 47 per million, respectively. However, the average number of centenarians in the Bulgarian mountains around the Teteven Municipality jumps to 139 per 1 million, or a 1.96-fold increase in centenarians, significantly associated with the water source they drink [141-142]. His research focused on the SW water properties, including electrical conductivity, mineral content, and H-bond strength in several natural drinking water sources. His studies reveal a strong relationship between the SW water properties in high-elevation shungite-filtered water sources and human health and longevity.

Other age-related hydration research indirectly confirms Ignatov's findings. Lorenzo [151] investigated the effects of hydration on aging. He states that hydration declines with age, suggesting BSW water also decreases with age. Kerch *et al*. investigated the effects of bound and free water on age-related diseases [152-153]. He states that the ratio of bound water to free water decreases with age, i.e., bound water gradually converts to a higher percentage of free water as humans age, which is correlated with a host of age-related diseases. These age-related hydration studies confirm that drinking SW water improves health and longevity, and conversely, the loss of BSW water, or bound water, is associated with age-related diseases.

As mentioned, drinking SW water with negative ORP values matches the BSW interfacial water properties with the negative cell membrane potential. The reviews by Yang and Brackenbury [68-69] state that malignant cells have lower negative cell membrane potentials. Their review states that the average membrane potential for nine malignant (tumor) cell types was ~24 mV. They also state that the average resting membrane potential for eight types of non-tumor cells was ~-72 mV. A concept article on the causes of cancer by Szigeti *et al*. [154] states that malignant cells have a lower membrane potential. They also conclude that cells undergoing division into daughter cells require tremendous energy, and healthy cells with negative membrane potentials can enter mitosis and remain non-malignant. These research findings indicate that cells' risk of becoming malignant or cancerous increases as membrane potentials decrease. In other words, as cell membrane potentials decrease from approximately -72 mV to -22 mV, the risk of cells becoming malignant substantially increases. Membrane potential is directly related to the depth of the BSW water zone, i.e., the deeper the EZ water zone or BSW interfacial water zone, the higher the negative membrane potential.

Several drinking water studies evaluated the effects of SW water on cancer cells or cancer patients. Ignatov *et al*. [154] investigated the effects of infrared light and high-frequency EMF field (2.3 x 10^7 MHz) treatments on water structures. They found that the water treatments increased H-bond strength in water and increased water structure. In a related study, Toshkova *et al*. [156] investigated the effects of the same infrared and EMF-treated water in a drinking water study with tumor-infected hamsters. They found that the infrared and EMF-treated water increased the H-bond strength in the blood plasma of mice with cancer. Also, they state that the infrared and EMF-treated water increased mitochondrial polarity or membrane potential. Finally, they stated that infrared and EMF-treated water increased the life span and decreased tumor growth in mice with cancer.

In collaboration with Dr. Pollack, a study by Hang *et al*. [157] they investigated the effects of a hydrophilic ceramic powder (QELBY powder) mixed with water to create SW water with EZ water properties. They found that QELBY powder increased the water structure. After mixing water with QEBLY powder (1% or 9,988 mg/l) and water for 0.5 h, the ORP of the water rose to -75 mV. Another study by Hang *et al*. [158] investigated the effects of water treatment using QELBY powder (10,000 mg/l) with an approximate ORP of -75 mV on Natural Killer (NK) cells and phagocytic activity in media cultures. The same QELBY water was also tested on viability for breast cancer cells (MCF-7 cell line). They found that NK cell activity increased from 8% (control) to 25% for the QELBY SW water treatments. Also, they found that phagocytic activity increased twofold for the QELBY water treatment. In addition, they show that breast cancer cell viability decreased by approximately 20% for the QELBY water treatment. Finally, they found that the mitochondrial membrane potential increased 1.36-fold with the QELBY treatment, indicating a deepening of the EZ zone that covers the mitochondria membrane [158].

A concept article by Mojica *et al*. [159] proposes that SW drinking water could be used as a hydration therapy for cancer patients. The underlying concept of this SW water research is that cells with adequate levels of BSW water and healthy negative ORP values reduce the risk for several types of cancer. This cell hydration concept was indirectly confirmed by a clinical study conducted by Mayrovitz [160]. He monitored breast cancer patients using non-invasive measurements to correlate water content in arm tissue with the risk of relapse for patients in cancer remission. He evaluated the ability of two portable medical devices to measure intracellular water content (IWC) in healthy patients and patients in remission from Breast Cancer-Related Lymphedema (BCRL). One device measured IWC using bioimpedance spectroscopy (BIS). The second device measured IWC using a Tissue Dielectric Constant (TDC) monitor to measure the dielectric properties of tissue. He found that both devices accurately measured IWC levels in patients with and without BCRL. He concluded that the non-invasive devices could reliably screen patients for BCRL symptoms based on their IWC levels from arm measurements. The findings from this study show that the level of intracellular water content could be used to predict or screen patients for their risk of relapse into cancer. The overall implications of this study suggest that the level of IWC water in human tissue could reliably correlate with certain cancer risks. As mentioned, ICW water comprises 64% BSW and 36% free water [80]. These findings agree with the concept paper by Mojica *et al*. [159] that adequate levels of BSW water would reduce the risk for several types of cancer. Mojica *et al*. suggest that cell membrane potential near -60 to -70 mV is a reliable biomarker for maintaining adequate BSW levels in humans. Yang and Brackenbury [68 -69] also agree that membrane potentials should be maintained near -70 mV, significantly decreasing cancer risk. These findings show that IWC water content and BSW interfacial water zone should be maintained at healthy levels to minimize cancer risks.

Aquaporins are protein-based water channels in cell and organelle membranes that allow rapid transfer of water and other low molecular weight molecules across the membranes. The aquaporin identified in mitochondria membranes is called AQP8. The AQP8 aquaporin assists with the transport of H_2O and H_2O_2 across the mitochondria's inner membrane. Ikaga *et al*. [161] found that “knocking out” the ability of AQP8 to function contributes to mitochondrial dysfunction. He also states that mitochondrial AQP8 contributes to mitochondrial respiratory function by maintaining water homeostasis [161]. This study highlights the importance of water transport across membranes and maintaining water and redox homeostasis for both intra and extracellular environments. Kozumi and Kitagawa [162] state that three different aquaporins preferentially transported SW water generated from a ceramic device. The increase in permeability for the aquaporins ranged from 21% to 26% when SW water was compared to non-structured water. Also, Ali *et al*. [163] found that four aquaporin types exhibited increased transport of natural healing spring water that had physicochemical properties comparable to structured water. Both studies suggest that human aquaporins are more permeable for SW and BSW water. The ability of a single aquaporin to rapidly transport water into cell organelles at rates up to 3 x 10^9 H_2O/s indicates how crucial aquaporins and structured water are for maintaining water homeostasis across both intra and cellular membranes. Maintaining the IWC: EWC ratio in cells as humans age is important so that BSW levels are at optimum levels for ultra-fast exchange of electrons and protons to preserve redox homeostasis at the cell and higher biological scales [1-9].

This review of the health benefits of drinking man-made or naturally sourced SW water reveals several impressive benefits. There are many more case studies for drinking naturally sourced SW than drinking man-made water products. Several other generation methods for drinking water have properties similar to SW water, including magnetized, electrolyzed, or hydrogen water. This article did not extensively review these methods of generating drinking water due to their limited information on their possible SW water properties.

5. EFFECTS OF INFRARED RADIATION ON BSW ZONE DYNAMICS

Energy from infrared radiation temporarily increases the thickness of the BSW interfacial water zone in plant or animal tissue when directly exposed to the radiation, according to Pollack [155]. This spectrum covers near, mid, and far ranges with associated wavelengths (Figure **2**). When a surface absorbs infrared radiation, radiative heat transfer occurs, and the temperature rises in that surface material. Water molecules readily absorb infrared radiation, especially in the far infrared spectrum. Near-infrared (NIR) has higher energy, penetrating deeper into tissue and raising tissue temperature faster than far infrared. As tissue absorbs NIR energy, it rises the temperature and is re-emitted at lower FIR energies that can be detected with thermal IR scans. Wein's law can be used to convert the temperature of an object into the infrared wavelength emitted from the object. For example, the average temperature of humans is 98 F, which converts to a FIR wavelength of 9,343 nm, based on Wein's law. Human mitochondria have an average temperature of 53-54 C, which converts to a FIR wavelength of 10,174 nm. Radiant heat from a temperature rise is constantly emitted in FIR wavelengths, but organic tissue can absorb a wide range of wavelengths in the EMF spectrum.

Pollack proposes that infrared radiation causes free water molecules to self-assemble into BSW water

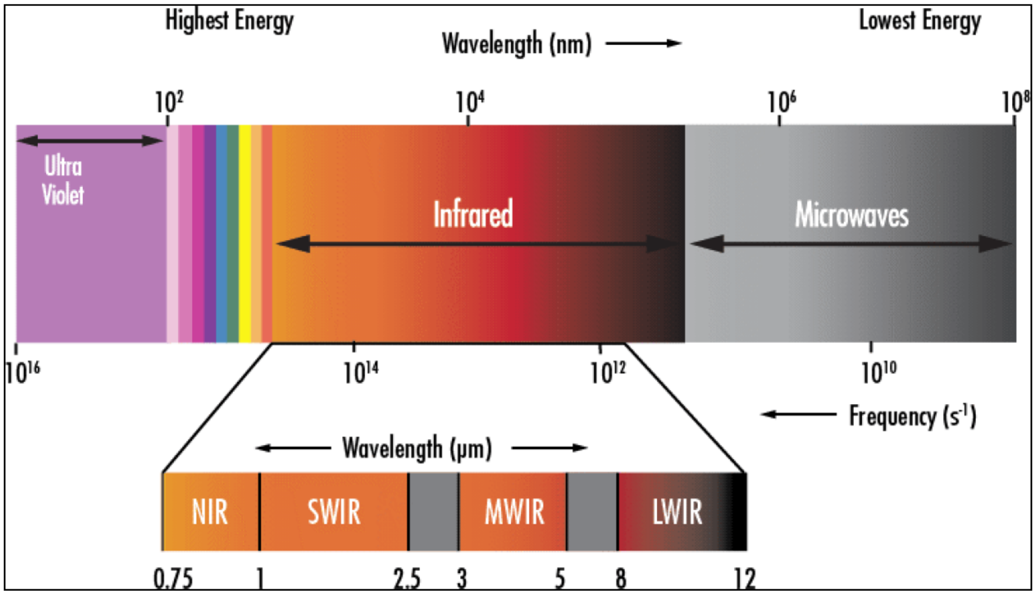

Figure 2: Infrared wavelength spectrum and associated wavelengths (open access image).

based on the absorption of IR energy by water molecules and altered electrostatic charges in the water molecules [155]. However, Pollack also states that the expanded EZ water zone is temporary and returns to its original size within about 10 min. He also states that the EZ zone maintains its new thickness if there is a continuous supply of IR energy from any source. All warm-blooded animals generate far infrared radiation during aerobic respiration in the hundreds of mitochondria in each cell. This infrared radiation emitted by mitochondria is absorbed by BSW interfacial water. Recycling and partial storage of heat generated by the mitochondria in BSW water improves overall metabolic efficiency, reduces energy demands, and supplies supplemental energy in the form of increased thickness of the EZ water zone. There is an intricate interplay between external and internal sources of IR radiation in creating and maintaining an adequate thickness for BSW water zones.

The interaction between IR energy and the electrostatics of energized water moles proposed by Pollack may also hint at the temporary nature of EZ water zone thickness [153]. The energy from IR radiation may be enough to split SW water that has been energized. However, the energy of IR radiation is too low to alter hydrogen bond strength in free or unstructured water. As mentioned in Part 1, when H-bonds are shortened, free water molecules increase in polymeric structures with much longer stability and duration dynamics. The shelf life of structured drinking water products is evidence of the stability of generated SW water. This author has custom-generated SW water that has maintained its physicochemical water properties for well over 12 months. Also, this author conducted a plant watering study using generated SW water [59]. The SW water was added to potting soil, which is highly reactive, and was then taken up into the roots of water-stressed plants. The study results indicate that the generated water maintained its SW water properties when transported in the soil matrix and the plant vascular system. Biological research is still uncertain whether BSW interfacial water has weaker H-bond strengths, less stability, and cyclic water zone dynamics than generated SW water using energy sources high enough to break the covalent bonds in water molecules. However, the bioenergy fields needed to maintain or increase BSW levels "*in vivo*" are probably too weak to shorten the H-bonds that ensure stable polymeric structures. It remains an open question whether drinking SW water with strong H-bonds would convert into BSW interfacial water with increased stability and prolonged duration spans. Also, it is still unclear if drinking high quality, generated SW water with strong H-bonds negatively impacts metabolic activities. The large volume of case studies for drinking natural or spring water with SW water properties and extending human longevity suggests only positive effects of drinking SW water. Part 3 of this review will describe several methods of generating SW water that produce shorter H-bonds and ensure stable SW water structures using energy sources strong enough to break the covalent bonds in water.

6. BIOMARKER MONITORING TO QUANTIFY EFFECTS OF DRINKING SW WATER ON HEALTH

The effects of SW water on human health can be monitored using home digital devices to measure four biomarkers. The biomarkers were heart rate, percent blood oxygen, body temperature, and Resting Energy Expenditure (REE). Personal biomarkers should be monitored after a prolonged rest period, as the biomarkers are also robustly synchronized to physical activity. In other words, these biomarkers are highly variable depending on any physical activity. Therefore, monitoring biomarkers while the body is at full rest provides more accurate results with less variation in averaging the results.

Essential biomarkers can be monitored with inexpensive devices. The heart pulse rate is measured with a finger oximeter that collects beats per minute (BPM). The oximeter also measures the percentage of blood oxygen. Digital thermometers measure body temperature when placed under the tongue. Also, indirect calorimeters measure Resting Energy Expenditure data [164]. The calorimeter data included volumetric oxygen consumption and estimates of calorie burn rates (kcal/day) while at rest and total calories per day.

Biomarkers for heart pulse rate and body temperature are easy to monitor daily over long periods. These biomarkers have taken on a new health monitoring status due to new research correlating the two biomarkers to a person's overall health status. Recent research has shown a direct, linear relationship between heart pulse rate and body temperature. Broman *et al*. [165] found that the heart rate increased by 8.35 BPM for every 1°C increase in body temperature between 32.0°C and 42.0°C in critically ill patients. Also, Neal *et al*. [166] found that in children under 16 years of age, the heart rate increased by 12.3 BPM for every 1 C increase in temperature after accounting for oxygen saturation, location of attendance, and age. Medical literature confirms that life spans are shortened as body temperature increases with increasing respiration rates [167-170]. Monitoring personal temperatures before and after drinking SW water should indicate a trend in reduced body temperature over time.

Research on aging shows a negative relationship between heart rates and longevity [171-173]. In a review by Jensen [174], he states that a reduction of 19% in resting heart rates (65 versus 80 bpm) was associated with 4.6 years longer life expectancy in men and 3.6 years in women. An earlier study by Jensen *et al*. [175] analyzed a large cohort study to estimate any associations between heart rates and longevity. A similar study was published by Woodward *et al*. [176]. They found that the health risk ratio was 1.0 for both sexes, with a resting heart rate of less than 60 BPM for heart failure and total mortality. Another meta-analyses study on heart rate and longevity by Quer *et al*. [177] involved a 92,000-person cohort study. They found that men's average resting heart rate at 70 years old was about 62 BPM. Again, personal monitoring with an oximeter before and after drinking SW water should show a trend in reducing heart pulse rates over time.

A portable indirect calorimeter measures aerobic respiration rates, i.e., the meter measures calories burned (kcal/day) when data is collected after different activities. In Part 1 of this review, the Water Respiration (WR) theory was presented as a cell energy source. If the WR energy cycle theory is ultimately proven valid, then total cell energy is a product of aerobic (AR) and water respiration (WR), along with secondary sources previously mentioned in Part 1. Water-based WR respiration is directly proportional to the level of BSW water available to initiate the WR cycle. In contrast, AR respiration requires a carbon-based energy source and O_2 to initiate the AR cycle within the mitochondria. As the AR respiration decreases and WR respiration increases, there is a reduction in REE and O_2 for aerobic respiration needs. Aerobic respiration consumes O_2; therefore, the percentage of blood oxygen is a direct biomarker for respiration status. Personal monitoring of REE rates requires collecting data before physical activity first thing in the morning. Monitoring REE rates before and after drinking SW water should show a trend in reduced REE rates over time.

Personal medical devices have been developed to monitor water content in body tissue remotely. Two types of portable meters have been designed to measure extracellular and intracellular water content remotely. One device uses bioimpedance spectroscopy (BIS). The BIS device sends a small electrical current into the body tissue over a range of frequencies and measures the impedance of the current. Algorithms convert the impedance values into biomarker estimates of body composition, including extracellular and intracellular water content. The accuracy of the BIS meters has been evaluated in several tests [178-180]. The second uses electrical current to measure the tissue's Tissue Dielectric Constant (TDC). The dielectric properties of tissue are directly proportional to its water content [181-182]. A comparison between BIS and TDC medical meters was conducted by Lahtinen *et al*. [183]. These meters allow daily monitoring of hydration levels and test for any enhancement of IWC levels due to drinking SW water.

7. ALTERNATIVE TREATMENTS FOR MAINTAINING BSW WATER LEVELS DURING AGING

The second part of this review focused on drinking SW water to maintain BSW water levels in humans or irrigated plants. However, research also reveals that two other treatments, including infrared light and magnetic fields, can increase BSW levels in organisms. These treatments for increasing BSW levels rely on exposing the body to energy fields that penetrate the tissue and induce self-assembly of free water into BSW water.

Additional research studies confirmed Pollack’s assertion that red and infrared light increases the EZ zone on membranes, which increases membrane potential [184- 188]. Sommer *et al*. [189-190] state that the bound water on mitochondria absorbs red to near-infrared radiation (R-NIR light) in Low-Level Light Therapy (LLLT) treatments. Medical treatments based on biophotomodulation or LLLT use red to near-infrared light to treat wound healing, stroke, traumatic brain injury, neurodegenerative conditions, cancer, *in vitro* fertilization, and pain management [190]. A review by Ravera *et al*. [191] states that biophotomodulation LLLT treatments positively affect cell-based bioenergetics. They also state that bound water, or EZ water, absorbs red to near-infrared light, which increases mitochondrial membrane potential. Passarella *et al*. [192] found that rat liver mitochondria had increased membrane potential and a 70% increase in ATP levels when the cells were exposed to red light (647 nm). Alexandratou *et al*. [193] showed a 30% increase in mitochondrial membrane potential with 15 s exposure to red light EMF (647 nm). A third study by Hu *et al*. [194] revealed a 34.5% increase in mitochondrial membrane potential when exposed to red light (633 nm). Yu *et al*. [195] found that photo modulation with NIR (660 nm) increased oxygen consumption twofold and increased membrane potential by 33% in rat liver mitochondria. A review by Yang and Youngblood [196] also states that biophotomodulation with red and near-infrared radiation can increase mitochondrial membrane potential and partially alleviate mitochondria dysfunction.

Research on the effects of static magnetic fields on water structure also shows some promise. Konovalov *et al*. [197] and Sidorenko *et al*. [198] collaborated on studies involving generating structured water with electromagnetic fields. They were able to form “nano-sized water assemblies” or water clusters up to 400 nm in size. These water clusters were estimated to contain up to 500 million H_2O molecules. Their findings suggest that electromagnetic fields can generate coherent domains, fully described in Part 1 of this review. Chang *et al*. [199] investigated the effects of static magnetic fields on water structure using molecular simulation models. They found that external magnetic fields from 0 to 10 T increased the number of hydrogen bonds in water, resulting in the formation of larger water clusters. Other studies by Cai *et al*. [200], Pang *et al*. [201], Jung *et al*. [202], and Ghauri *et al*. [203] found that magnetic fields increase water structure based on the enhancement of several SW water properties. A study by Shalatonin and Pollack [204] found that a neodymium bar magnet (1,440 mT) increased the EZ water zone on microspheres.

These studies were conducted under laboratory conditions, so one can only conjecture whether magnetic fields can increase BSW water levels by placing static magnets on the organism's surface. Mohamed and Hanafy [205] found that water exposed to static magnetic field (2 mT) for 1 h exhibited SW water properties by increasing pH by 11.6%, viscosity by 10%, and electrical conductivity by 10%. They used the same magnetized water to irrigate common beans (*Phaseolus vulgaris*), resulting in a 7.9% increase in plant height and a 13% increase in weight of 100 seeds compared to the control plants. Despite the low magnetic field strength (2 mT), their irrigation study showed increased plant responses based on plant, seed, and chlorophyll variables. Magnetic fields increase the hydrogen bond numbers in water, which increases water structure, depending on the magnetic field strength and duration of exposure [206-207]. The effects of different energy fields, including the strength and duration of exposure to different fields, on altering H-bond strength in liquid water will be briefly discussed in Part 3.

8. BSW WATER EFFECTS ON INNATE IMMUNITY AND VIRUS ATTACHMENT TO MEMBRANES

BSW water can boost human immunity via two different processes. The first process boosts the redox activities within the innate immune system. The innate immune system is the “first responder” immunity system that goes into action immediately. The innate immunity cells surround and engulf the invader or produce free radicals that chemically inactivate the pathogens. Innate immunity is non-specific and includes responses such as phagocytosis, killing of pathogens or cells, and cytokine production. The second process involves the ability of BSW water to increase cell membrane rigidity by the semi-flexible liquid crystalline coating on membrane surfaces.

The innate system includes leukocytes, such as neutrophils, that generate free radical oxygen species [208-209]. When the immune system signals are sent to neutrophils, the enzyme NADPH oxidase is activated to produce free radicals [210-212]. NADPH oxidase can generate a respiratory burst that can increase oxygen consumption by 10-15-fold [210-212]. The innate immune system uses this rapid increase in Radical Oxygen Species (ROS) to inactivate pathogens through a series of redox reactions [213-215]. Hang *et al*. [158] found that Natural Killer cell activity increased from 8% to 25% for the control and SW water treatments, respectively. Also, they found that phagocytic activity increased twofold for the SW water treatment. As mentioned in Part 1, excess ROS radicals can be rapidly quenched when adequate BSW water levels are present due to their excellent antioxidant properties.

Pollack *et al*. [184-187] conclude that the EZ zone, a.k.a. BSW interfacial layer, excludes virtually all ions, solutes, and pathogens. Shalatonin [216] states that a long-range EMF interaction between the EZ water and SARS-CoV-2 glycosylated spikes creates a “glass-like” hydration layer that covers the cell membrane. Many research phrases are vague descriptions such as “glass-like,” but this phrase suggests that the glass-like hydration layer is synonymous with a liquid crystalline lattice of H-bonded water molecules hydration layer. This glass-like hydration layer inhibits the entry of the

SARS-CoV virus into a host cell. She concludes that viral interactions with EZ water may also be able to exclude human immunodeficiency viruses, influenza viruses, and possibly other enveloped viruses. A concept paper by Messori [217] states that viruses such as SARS-CoV-2 seek host cells via long-range emission of ULF-EMF signals. These EMF signals are the electromagnotaxis principle that viruses use to seek out and find host cells. The EMF signals also alert the host cells to initiate a cascade of redox reactions to generate ROS radicals. The same ULF-EMF signals also create a glass-like stabilizing EZ zone that inhibits viral attachment to host cells [217].

Chen *et al*. [218] investigated the strength of the exclusion force in the EZ water zone. They found that negatively charged microspheres were repelled from an EZ zone on a Nafion surface with a force increasing from 0 to 3 pN as the microsphere distance decreased from 60 to 0 μm from the surface. The SARS-CoV-2 virus is negatively charged on its outside surface. Therefore, SARS-CoV-2 should be repelled from negatively charged EZ water zones that also repelled the negatively charged microspheres in the study by Chen *et al*. [218]. Cheng and Moraru [219] evaluated the effects of long-range interactions between structured water generated as an EZ water zone on a Nafion surface and bacteria. They found that an EZ water zone excluded *Staphylococcus aureus*, *Escherichia coli* O157:H7, and *Listeria monocytogenes* from 40-60 μm from the surface, with an additional transition zone of 40-80 μm for bacteria suspended in tryptic soy broth. Kowacz and Pollack [220] evaluated the ability of propolis (bee glue) to create an EZ water zone. They state that Propolis created an EZ zone over 40 min., approximately 200-300 μm thick, and was stable for about two h before diminishing in depth. They state that the propolis-generated EZ zone created an effective exclusion zone that prevented the attachment of viruses or entry of pathogen bacteria.

These research findings indicate that viral entry into host cells is associated with the depth of BSW interfacial water covering the host cell membrane. Further research is needed to investigate the effects of maintaining and enhancing BSW interfacial water on inhibiting virus entry into host cells. Additional research is required to investigate the interplay between BSW water levels, ROS generation and quenching, ROS inactivation of pathogens, and boosting overall cell immunity.

REFERENCES

[1] Cardarella J, Turner J, Lo SY. A Soft Matter State of Water and the Structures it Forms Onco Therapeutics 2012; 3(3-4). https://www.researchgate.net/publication/274815653_A_Soft_Matter_State_of_Water_and_the_Structures_it_Forms?enrichId=rgreq-a600d8378f3b7ab0e72b6236be7201a7-.

[2] Kim Y, Bertagna F, D'souza EM, Heyes DJ, Johannissen LO, Nery ET, Pantelias A, Sanchez-Pedreño Jimenez A, Slocombe L, Spencer MG, Al-Khalili J. Quantum biology: An update and perspective. Quantum Reports 2021; 3(1): 80-126. https://doi.org/10.3390/quantum3010006

[3] Moser CC, Dutton PL. Outline of theory of protein electron transfer. Protein electron transfer 2020; pp. 1-21. Garland Science. https://doi.org/10.1201/9781003076803-1

[4] Pang XF. Properties of proton transfer in hydrogen-bonded systems and its experimental evidence and applications in biology. Progress in Biophysics and Molecular Biology 2013; 112(1-2): 1-32. https://doi.org/10.1016/j.pbiomolbio.2012.11.003

[5] Cui Q, Karplus M. Is a "proton wire" concerted or stepwise A model study of proton transfer in carbonic an hydrase. The Journal of Physical Chemistry B 2003; 107(4): 1071-8. https://doi.org/10.1021/jp021931v

[6] Salna B, Benabbas A, Sage JT, van Thor J, Champion PM. Wide-dynamic-range kinetic investigations of deep proton tunneling in proteins. Nature Chemistry 2016; 8(9): 874-80. https://doi.org/10.1038/nchem.2527

[7] Odella E, Secor M, Reyes Cruz EA, Guerra WD, Urrutia MN, Liddell PA, Moore TA, Moore GF, Hammes-Schiffer S, Moore AL. Managing the redox potential of PCET in grotthuss-type proton wires. Journal of the American Chemical Society 2022; 144(34): 15672-9. https://doi.org/10.1021/jacs.2c05820

[8] Odella E, Mora SJ, Wadsworth BL, Goings JJ, Gervaldo MA, Sereno LE, Groy TL, Gust D, Moore TA, Moore GF, Hammes-Schiffer S. Proton-coupled electron transfer across benzimidazole bridges in bioinspired proton wires. Chemical science 2020; 11(15): 3820-8. https://doi.org/10.1039/C9SC06010C

[9] Goings JJ, Hammes-Schiffer S. Nonequilibrium dynamics of proton-coupled electron transfer in proton wires: concerted but asynchronous mechanisms ACS. Central Science 2020; 6(9): 1594-601. https://doi.org/10.1021/acscentsci.0c00756

[10] Ying W. NAD+ and NADH in cellular functions and cell death. Front Biosci 2006; 11(1): 3129-48. https://doi.org/10.2741/2038

[11] Houtkooper RH, Cantó C, Wanders RJ, Auwerx J. The secret life of NAD+: an old metabolite controlling new metabolic signaling pathways. Endocrine reviews 2010; 31(2): 194-223. https://doi.org/10.1210/er.2009-0026

[12] Chu XY, Xu YY, Tong XY, Wang G, Zhang HY. The legend of ATP: From the origin of life to precision medicine. Metabolites 2022; 12(5): 461. https://doi.org/10.3390/metabo12050461

[13] Takihara Y, Sudo D, Arakawa J, Takahashi M, Sato A, Tanuma SI, Uchiumi F. Nicotinamide adenine dinucleotide (NAD+) and cell aging. New Research on Cell Aging and Death. Hauppauge, NY: Nova Science Publishers 2018; 1: 131-58. https://doi.org/10.1007/978-3-319-69892-2_1035-1

[14] Srivastava S. Emerging therapeutic roles for NAD+ metabolism in mitochondrial and age-related disorders. Clinical and translational medicine 2016; 5: 1-1. https://doi.org/10.1186/s40169-016-0104-7

[15] Covarrubias AJ, Perrone R, Grozio A, Verdin E. NAD+ metabolism and its roles in cellular processes during ageing. Nature Reviews Molecular Cell Biology 2021; 22(2): 119-41.
https://doi.org/10.1038/s41580-020-00313-x

[16] Strømland Ø, Diab J, Ferrario E, Sverkeli LJ, Ziegler M. The balance between NAD+ biosynthesis and consumption in ageing. Mechanisms of Ageing and Development 2021; 199: 111569.
https://doi.org/10.1016/j.mad.2021.111569

[17] Griffiths HB, Williams C, King SJ, Allison SJ. Nicotinamide adenine dinucleotide (NAD+): Essential redox metabolite, co-substrate and an anti-cancer and anti-ageing therapeutic target. Biochemical Society Transactions 2020; 48(3): 733-44.
https://doi.org/10.1042/BST20190033

[18] Strømland Ø, Diab J, Ferrario E, Sverkeli LJ, Ziegler M. The balance between NAD+ biosynthesis and consumption in ageing. Mechanisms of Ageing and Development 2021; 199: 111-569.
https://doi.org/10.1016/j.mad.2021.111569

[19] Waddell J, Khatoon R, Kristian T. Cellular and Mitochondrial NAD Homeostasis in Health and Disease. Cells 2023; 12(9): 1329.
https://doi.org/10.3390/cells12091329

[20] Sohal RS, Toy PL, Farmer KJ. Age-related changes in the redox status of the housefly, Musca domestica. Archives of gerontology and geriatrics 1987; 6(2): 95-100.
https://doi.org/10.1016/0167-4943(87)90001-X

[21] Farmer KJ, Sohal RS. Relationship between superoxide anion radical generation and aging in the housefly, Musca domestica. Free Radical Biology and Medicine 1989; 7(1): 23-9.
https://doi.org/10.1016/0891-5849(89)90096-8

[22] Sakashita N, Watanabe HC, Ikeda T, Saito K, Ishikita H. Origins of water molecules in the photosystem II crystal structure. Biochemistry 2017; 56(24): 3049-57.
https://doi.org/10.1021/acs.biochem.7b00220

[23] Sakashita N, Ishikawa H, Saito K. Rigidly hydrogen-bonded water molecules facilitate proton transfer in photosystem II. Physical Chemistry. Chemical Physics 2020; 22(28): 15831-41.
https://doi.org/10.1039/D0CP00295J

[24] Li X, Li Z, Yang J. Proposed photosynthesis method for producing hydrogen from dissociated water molecules using incident near-infrared light. Physical review letters 2014; 112(1): 018301.
https://doi.org/10.1103/PhysRevLett.112.018301

[25] Linke K, Ho FM. Water in Photosystem II: structural, functional and mechanistic considerations. Biochimica et Biophysica Acta (BBA)-Bioenergetics 2014; 1837(1): 14-32.
https://doi.org/10.1016/j.bbabio.2013.08.003

[26] Takaoka T, Sakashita N, Saito K, Ishikita H. p K a of a proton-conducting water chain in photosystem II. The Journal of Physical Chemistry Letters 2016; 7(10): 1925-32.
https://doi.org/10.1021/acs.jpclett.6b00656

[27] Bondar AN, Dau H. Extended protein/water H-bond networks in photosynthetic water oxidation. Biochimica et Biophysica Acta (BBA)-Bioenergetics 2012; 1817(8): 1177-90.
https://doi.org/10.1016/j.bbabio.2012.03.031

[28] Hussein R, Ibrahim M, Bhowmick A, Simon PS, Chatterjee R, Lassalle L, Doyle M, Bogacz I, Kim IS, Cheah MH, Gul S. Structural dynamics in the water and proton channels of photosystem II during the S2 to S3 transition. Nature communications 2021; 12(1): 6531.
https://doi.org/10.1038/s41467-021-26781-z

[29] Doyle MD, Bhowmick A, Wych DC, Lassalle L, Simon PS, Holton J, Sauter NK, Yachandra VK, Kern JF, Yano J, Wall ME. Water Networks in Photosystem II Using Crystalline Molecular Dynamics Simulations and Room-Temperature XFEL Serial Crystallography. Journal of the American Chemical Society 2023; 145(27): 14621-35.
https://doi.org/10.1021/jacs.3c01412

[30] Ho MW. Large supramolecular water clusters caught on camera-a review. Water 2014; 6: 1-2.

[31] Ho MW. Illuminating water and life: Emilio Del Giudice Electromagnetic biology and medicine 2015; 34(2): 113-22.
https://doi.org/10.3109/15368378.2015.1036079

[32] Gauthier PP, Battle MO, Griffin KL, Bender ML. Measurement of gross photosynthesis, respiration in the light, and mesophyll conductance using H2 18O labeling. Plant Physiology 2018; 177(1): 62-74.
https://doi.org/10.1104/pp.16.00741

[33] Sarraf M, Kataria S, Taimourya H, Santos LO, Menegatti RD, Jain M, Ihtisham M, Liu S. Magnetic field (MF) applications in plants: An overview. Plants 2020; 9(9): 1139.
https://doi.org/10.3390/plants9091139

[34] Saletnik B, Saletnik A, Słysz E, Zaguła G, Bajcar M, Puchalska-Sarna A, Puchalski C. The static magnetic field regulates the structure, biochemical activity, and gene expression of plants. Molecules 2022; 27(18): 5823.
https://doi.org/10.3390/molecules27185823

[35] Alattar E, Radwan E, Elwasife K. Improvement in growth of plants under the effect of magnetized water. AIMS Biophysics 2022; 9(4): 346-87.
https://doi.org/10.3934/biophy.2022029

[36] Gora MK, Jakhar KC, Jat H, Kumar P. A review: structured water technology: its effect on productivity of agricultural crops. Int J Chem Stud 2018; 4: 3248-53.

[37] Tu R, Jin W, Xi T, Yang Q, Han SF, Abomohra AE. Effect of static magnetic field on the oxygen production of Scenedesmus obliquus cultivated in municipal wastewater. Water research 2015; 86: 132-8.
https://doi.org/10.1016/j.watres.2015.07.039

[38] Yang G, Wang J, Mei Y, Luan Z. Effect of magnetic field on protein and oxygen-production of Chlorella vulgaris. Mathematical and Physical Fisheries Science 2011; 9(1): 116-26.

[39] Water Acitivy slides. https://www.slideshare.net/AbelJacobThomas/water-activity-and-different-instruments-to-determine-aw

[40] Differential Scanning Calorimetry. https://en.wikipedia.org/wiki/Differential_scanning_calorimetry

[41] Fernández-Marín B, Kranner I, Sebastián MS, Artetxe U, Laza JM, Vilas JL, Pritchard HW, Nadajaran J, Míguez F, Becerril JM, García-Plazaola JI. Evidence for the absence of enzymatic reactions in the glassy state. A case study of xanthophyll cycle pigments in the desiccation-tolerant moss Syntrichiaruralis. Journal of Experimental botany 2013; 64(10): 3033-43.
https://doi.org/10.1093/jxb/ert145

[42] Buitink J, Leprince O. Glass formation in plant anhydrobiotes: survival in the dry state. Cryobiology 2004; 48(3): 215-28.
https://doi.org/10.1016/j.cryobiol.2004.02.011

[43] Kunzek H, Müller S, Vetter S, Godeck R. The significance of physicochemical properties of plant cell wall materials for the development of innovative food products. European Food Research and Technology 2002; 214: 361-76.
https://doi.org/10.1007/s00217-002-0487-0

[44] Hoekstra FA, Golovina EA, Buitink J. Mechanisms of plant desiccation tolerance. Trends in plant science 2001; 6(9): 431-8.
https://doi.org/10.1016/S1360-1385(01)02052-0

[45] CandottoCarniel F, Fernandez-Marín B, Arc E, Craighero T, Laza JM, Incerti G, Tretiach M, Kranner I. How dry is dry? Molecular mobility in relation to thallus water content in a lichen. Journal of Experimental Botany 2021; 72(5): 1576-88.
https://doi.org/10.1093/jxb/eraa521

[46] Agbicodo EM, Fatokun CA, Muranaka S, Visser RG, Linden Van Der CG. Breeding drought tolerant cowpea: constraints, accomplishments, and future prospects. Euphytica 2009; 167: 353-70. https://doi.org/10.1007/s10681-009-9893-8

[47] Rascio A, Altamura G, Pecorella I, Goglia L, Sorrentino G. Physiological mechanisms preventing plant wilting under heat stress: a case study on a wheat (Triticum durum Desf.) bound water-mutant. Environmental and Experimental Botany 2023: 105502. https://doi.org/10.1016/j.envexpbot.2023.105502

[48] Rascio A, Platani C, Di Fonzo N, Wittmer G. Bound water in durum wheat under drought stress. Plant Physiology 1992; 98(3): 908-12. https://doi.org/10.1104/pp.98.3.908

[49] Rascio A. Bound water in plants and its relationships to the abiotic. Rec Res Dev Plant Physiol 1997; 1: 215-2.

[50] Ergashovich KA, Toshtemirovna NU, Raximovna AK, Abdullaevna FF. The properties of cotton resistance and adaptability to drought stress. Journal of Pharmaceutical Negative Results 2022; 13(4): 958-61.

[51] Singh V, Pallaghy CK, Singh D. Phosphorus nutrition and tolerance of cotton to water stress: II. Water relations, free and bound water and leaf expansion rate. Field crops research 2006 Apr 30; 96(2-3): 199-206. https://doi.org/10.1016/j.fcr.2005.06.011

[52] Jecmenica M, Kravić N, Vasić M, Živanović T, Mandić V, Damnjanović J, Dragičević V. Genetic variability of free energy in a function of drought tolerance in common bean accessions. Genetika 2016; 48(3): 1003-15. https://doi.org/10.2298/GENSR1603003J

[53] Zhang SZ, Yang BP, Feng CL, Chen RK, Luo JP, Cai WW, Liu FH. Expression of the Grifolafrondosa trehalose synthase gene and improvement of drought□tolerance in sugarcane (Saccharum officinarum L.). Journal of Integrative Plant Biology 2006; 48(4): 453-9. https://doi.org/10.1111/j.1744-7909.2006.00246.x

[54] Wang XM, Zhao L, Yan BG, Shi LT, Liu GC, He YX. Morphological and physiological responses of Heteropogoncontortus to drought stress in a dry-hot valley. Botanical Studies 2016; 57: 1-2. https://doi.org/10.1186/s40529-016-0131-0

[55] Yukui J, Fengmin LU, Jingbo ZH, Junliang G, Zhiming X, Fang L. Drought Resistance of Twelve Desert Shrubs at Seedling Stage of Ulan Buh Desert Ecosystem. Journal of Landscape Research 2016; 8(6): 83.

[56] Biswas S, Das R. Structured Water: An Innovative Irrigation Option in Agriculture. Agriculture and Food 2022; 4(01): 342-4.

[57] Gora MK, Jakhar KC, Jat H, Kumar P. A review: structured water technology: its effect on productivity of agricultural crops. Int J Chem Stud 2018; 4: 3248-53.

[58] Dubey PK. Structured water: an exciting new field in water science. International Journal of Agriculture Sciences, ISSN 2018: 0975-3710.

[59] Ramsey CL. Application of a structured water generator for crop irrigation: Structured water, drought tolerance, and alteration of plant defense mechanisms to abiotic stressors. J Basic Appl Sci 2021; 17: 127-52. Abstract: A greenhouse study was conducted to enhance drought tolerance in velvet bean plants. https://doi.org/10.29169/1927-5129.2021.17.14

[60] Manoj KM, Tamagawa H. A critical appraisal on cellular homeostasis, transduction of environmental stimuli, and the elicitation of electrophysiological responses. OSF Preprints 2020.

[61] James CN, Copeland RC, Lytle DA. Relationships between oxidation-reduction potential, oxidant, and pH in drinking water. Proc 2004 AWWA WQTC, San Antonio, Texas 2004 Nov 14.

[62] http://www.molecularhydrogeninstitute.com/importance-of-oxidation-reduction-potential-orp

[63] https://www.eautarcie.org/en/03d3.html

[64] https://www.icmag.com/filedata/fetch?id=12600157

[65] https://www.yokogawa.com/us/library/resources/white-papers/basics-of-orp/#: ~: text=ORP%20is%20similar%20to%20pH,electron%20activity%20within%20the%20solution.http://chinese.mretwater.com.sg/downloads/mret-article-alzheimers-disease.pdf

[66] Ling GN. A new theoretical foundation for the polarized-oriented multilayer theory of cell water and for inanimate systems demonstrating long-range dynamic structuring of water molecules. Physiological chemistry and physics and medical NMR 2003; 35(2): 91-130.

[67] Pokorný J, Pokorný J, Borodavka F. Warburg effect—damping of electromagnetic oscillations. Electromagnetic Biology and Medicine 2017; 36(3): 270-8. https://doi.org/10.1080/15368378.2017.1326933

[68] Yang M, Brackenbury WJ. Membrane potential and cancer progression. Frontiers in physiology 2013; 4: 185. https://doi.org/10.3389/fphys.2013.00185

[69] Yang M, Brackenbury WJ. Harnessing the membrane potential to combat cancer progression. Bioelectricity 2022; 4(2): 75-80. https://doi.org/10.1089/bioe.2022.0001

[70] Lindinger MI. Structured water: effects on animals. Journal of Animal Science 2021; 99(5): 063. https://doi.org/10.1093/jas/skab063

[71] Johansson B, Sukhotskya S. Drinking functional coherent mineral water accompanies a strengthening of the very low frequency impact on heart rate variability, and mono and multifractal heart rhythm dynamics in healthy humans. Functional Foods in Health and Disease 2016 ; 6(6): 388-413. https://doi.org/10.31989/ffhd.v6i6.265

[72] Matsiyevska O. Influence of the redox potential of different water quality on the human blood. Технологический аудит и резервы производства 2017; 1(3 (33)). https://doi.org/10.15587/2312-8372.2017.93633

[73] Martin Chaplin. https://water.lsbu.ac.uk/water/water_sitemap.html.

[74] Chumlea *et al.* (1999). Total body water data for white adults 18 to 64 years of age: the Fels longitudinal study. https://doi.org/10.1046/j.1523-1755.1999.00532.x

[75] Messori C, Prinzera SV, di Bardone FB. Deep into the water: Exploring interfacial water's hydro-electromagnetic and quantum-electrodynamic properties in living systems. Open Access Library Journal 2019; 6(05): 1. https://doi.org/10.4236/oalib.1105435

[76] Serra-Prat *et al.* (2019). Intracellular water content in lean mass is associated with muscle strength, functional capacity, and frailty in community-dwelling elderly individuals—a cross-sectional study. https://doi.org/10.3390/nu11030661

[77] Lichtenbelt *et al.* (1999). Increased extracellular water compartment, relative to intracellular compartment, after weight reduction. https://doi.org/10.1152/jappl.1999.87.1.294

[78] Zhang *et al.* (2019). Association between intracellular and extracellular fluid content and the amount of water intake among Chinese college students. https://doi.org/10.1186/s12986-019-0397-9

[79] Popkin *et al.* (2010). Water, hydration, and health. https://doi.org/10.1111/j.1753-4887.2010.00304.x

[80] Shi L, Hu F, Min W. Optical mapping of biological water in single live cells by stimulated Raman excited fluorescence microscopy. Nature communications 2019; 10(1): 4764. https://doi.org/10.1038/s41467-019-12708-2

[81] Guo Y, Zhang M, Xie Y, Chen H, Xiao Z. Effect of Thermal Treatment on the Heat of Vaporization of Bound Water by NMR and DSC Analysis. BioResources 2018; 13(3): 5534-42. https://doi.org/10.15376/biores.13.3.5534-5542

[82] Custodis F, Reil JC, Laufs U, Böhm M. Heart rate: a global target for cardiovascular disease and therapy along the cardiovascular disease continuum. Journal of cardiology 2013; 62(3): 183-7 https://doi.org/10.1016/j.jjcc.2013.02.018

[83] Tverdal A, Hjellvik V, Selmer R. Heart rate and mortality from cardiovascular causes: a 12-year follow-up study of 379 843 men and women aged 40–45 years. European heart journal 2008; 29(22): 2772-81. https://doi.org/10.1093/eurheartj/ehn435

[84] Zhang GQ, Zhang W. Heart rate, lifespan, and mortality risk. Ageing research reviews 2009 Jan 1; 8(1): 52-60. https://doi.org/10.1016/j.arr.2008.10.001

[85] Lorenzo I, Serra-Prat M, Yébenes JC. The role of water homeostasis in muscle function and frailty: a review. Nutrients 2019; 11(8): 1857. https://doi.org/10.3390/nu11081857

[86] Kerch G. Role of changes in state of bound water and tissue stiffness in development of age-related diseases. Polymers 2020; 12(6): 1362.

https://doi.org/10.3390/polym12061362

[87] Kerch G. Distribution of tightly and loosely bound water in biological macromolecules and age-related diseases. International journal of biological macromolecules 2018; 118: 1310-8. https://doi.org/10.1016/j.ijbiomac.2018.06.187

[88] Jéquier E, Constant F. Water as an essential nutrient: the physiological basis of hydration. European journal of clinical nutrition 2010; 64(2): 115-23. https://doi.org/10.1038/ejcn.2009.111

[89] Bedogni G, Borghi A, Battistini N. Body water distribution and disease. Acta Diabetologia 2003; 40. https://doi.org/10.1007/s00592-003-0065-3

[90] Lavizzo-Mourey RJ. Dehydration in the elderly: a short review. Journal of the National Medical Association 1987 Oct; 79(10): 1033.

[91] Hooper L, Bunn D, Jimoh FO, Fairweather-Tait SJ. Water-loss dehydration and aging. Mechanisms of Ageing and Development 2014 Mar 1; 136: 50-8. Ignatov I, Mosin OV. Hydrogen Bonds among Molecules in Liquid and Solid State of Water. Modifications of Ice Crystals. Journal of Health, Medicine and Nursing 2014; 5: 56-79. https://doi.org/10.1016/j.mad.2013.11.009

[92] Description of drinking water products. https://mytapscore.com/blogs/tips-for-taps/what-s-the-function-of-functional-water

[93] Ostojic SM. Serum alkalinization and hydrogen-rich water in healthy men. InMayo Clinic Proceedings 2012; 87(5): 501-502. Elsevier. https://doi.org/10.1016/j.mayocp.2012.02.008

[94] Ostojic SM, Stojanovic MD. Hydrogen-rich water affected blood alkalinity in physically active men. Research in Sports Medicine 2014; 22(1): 49-60. https://doi.org/10.1080/15438627.2013.852092

[95] Drid P, Trivic T, Casals C, Trivic S, Stojanovic M, Ostojic SM. Is molecular hydrogen beneficial to enhance post-exercise recovery in female athletes?. Science & Sports 2016; 31(4): 207-13. https://doi.org/10.1016/j.scispo.2016.04.010

[96] Hydrogen water (Kangen water) https://www.eautarcie.org/en/03d2.html

[97] Fisher BD, Gauvin C, Neeser KJ, Smirnov IV. Bioimpedance analysis to determine the extracellular/intracellular water exchange of MRET-activated water compared to control water. Nutrition and metabolism 6: 7.

[98] Smirnov link. http://mret-water.com/scientific-studies/#section6

[99] Johansson B and Sukhotskya S. Drinking functional coherent mineral water accompanies a strengthening of the very low frequency impact on heart rate variability, and mono and multifractal heart rhythm dynamics in healthy humans. Functional Foods in Health and Disease 2016; 6(6): 388-413. https://doi.org/10.31989/ffhd.v6i6.265

[100] Smirnov IV. Mechanism of Possible Biological Effect of Activated Water on Patients Suffering from Alzheimer's Disease. ResearchGate.net 2003; 12: 44-6. https://www.newg7.com/en/whats-neug7_en.html

[101] Smirnov IV. MRET Water Effect in the TgCRND8 Transgenic Amyloid Mice. Journal of Clinical and Experimental Neuroscience 2013; 1: 6. https://doi.org/10.12966/jcen.11.02.2013

[102] KorotkovKG, Churganov OA, Gavrilova EA, Belodedova MA, Korotkova AK. Influence of drinking structured water to human psychophysiology. J Appl Biotechnol Bioeng 2019; 6(4): 171. https://doi.org/10.15406/jabb.2019.06.00190

[103] Martin WJ. The Alternative Cellular Energy (ACE) Pathway as the Foundation for a New Paradigm in Medicine. Int J Complement Alt Med 2017; 9(6): 00314. https://doi.org/10.15406/ijcam.2017.09.00314

[104] Martin WJ. The many biological functions of the alternative cellular energy (ACE) pathway. Int J Complement Alt Med 2017; 7(5): 00237. https://doi.org/10.15406/ijcam.2017.07.00237

[105] Martin WJ. Insufficiency of cellular energy (ICE): The basis for many illnesses potentially correctable using KELEA activated water. International Journal Complementary & Alternative Medicine 2016; 4(1): 00106. https://doi.org/10.15406/ijcam.2016.04.00106

[106] Martin WJ. Sustainable Increase in Emotional Wellness Achievable by Enhancing the Alternative Cellular Energy (ACE) Pathway with KELEA Activated Water.

[107] Narayanan CR, Korotkov K, Srinivasan TM. Bioenergy and its implication for yoga therapy. International Journal of Yoga 2018; 11(2): 157. https://doi.org/10.4103/ijoy.IJOY_54_17

[108] Johansson B. Functional Water-In Promotion of Health Beneficial Effects and Prevention of Disease. Internal Medicine Review 2016; 3(3). https://doi.org/10.18103/imr.v3i2.321

[109] Jhon MS. Role of Water as Our Life Expectancy due to the Agings and Various Cancers. Bulletin of the Korean Chemical Society 1989; 10(2): 206-8.

[110] Szalkai I. The Effect of High Oxygen Level (Kaqun) Water and the Ability to Use It to Maintain Military Combat Tone. Academic and Applied Research in Military and Public Management Science 2017; 16(3): 35-48. https://doi.org/10.32565/aarms.2017.3.2

[111] Saltmarche AE, Naeser MA, Ho KF, Hamblin MR, Lim L. Significant improvement in cognition in mild to moderately severe dementia cases treated with transcranial plus intranasal photobiomodulation: case series report. Photomedicine and laser surgery 2017; 35(8): 432-41. https://doi.org/10.1089/pho.2016.4227

[112] Chai B, Yoo H, Pollack GH. Effect of radiant energy on near-surface water The Journal of Physical Chemistry B 2009; 113(42): 13953-8. https://doi.org/10.1021/jp908163w

[113] Chao LL. Effects of home photobiomodulation treatments on cognitive and behavioral function, cerebral perfusion, and resting-state functional connectivity in patients with dementia:

a pilot trial. Photobiomodulation, photomedicine, and laser surgery 2019; 37(3): 133-41.
https://doi.org/10.1089/photob.2018.4555

[114] Hamblin MR. Photobiomodulation for Alzheimer's disease: has the light dawned?. InPhotonics 2019; 6(3): 77. MDPI.
https://doi.org/10.3390/photonics6030077

[115] Chan AS, Lee TL, Yeung MK, Hamblin MR. Photo biomodulation improves the frontal cognitive function of older adults. International journal of geriatric psychiatry 2019; 34(2): 369-77.
https://doi.org/10.1002/gps.5039

[116] Wang ZY, Zhou ZC, Zhu KN, Wang X, Pan JG, Lorenzen LH, Zhou MC. Microclustered water and hydration. Asia Pacific Journal of Clinical Nutrition 2004; 13.

[117] Liguori A, Brizhik L, Liguori S, Silli L, Bangrazi S, Petti F, Pinti M, Pistelli MI, Giuliani L. Effects of Ion Cyclotron Frequencies on Human Resistance and Reactance in 31 Healthy Subjects. Radiation 2022; 2(4): 357-75.
https://doi.org/10.3390/radiation2040027

[118] Chang KT, Weng CI. The effect of an external magnetic field on the structure of liquid water using molecular dynamics simulation. Journal of Applied physics 2006; 100(4).
https://doi.org/10.1063/1.2335971

[119] Cai R, Yang H, He J, Zhu W. The effects of magnetic fields on water molecular hydrogen bonds. Journal of molecular structure 2009; 938(1-3): 15-9.
https://doi.org/10.1016/j.molstruc.2009.08.037

[120] Gang N, St-Pierre LS, Persinger MA. Water dynamics following treatment by one hour 0.16 Tesla static magnetic fields depend on exposure volume. Water 2012; 3: 122-31.

[121] Pang X, Deng B. Investigation of changes in properties of water under the action of a magnetic field. Science in China Series G: Physics, Mechanics and Astronomy 2008; 51(11): 1621-32.
https://doi.org/10.1007/s11433-008-0182-7

[122] Ibrahim IH. Biophysical properties of magnetized distilled water. Egypt. J. Sol 2006; 29(2): 1-7.
https://doi.org/10.21608/ejs.2006.149287

[123] Holysz L, Szczes A, Chibowski E. Effects of a static magnetic field on water and electrolyte solutions. Journal of Colloid and Interface Science 2007; 316(2): 996-1002.
https://doi.org/10.1016/j.jcis.2007.08.026

[124] Lindinger MI. Structured water: effects on animals. Journal of Animal Science 2021; 99(5): skab063.
https://doi.org/10.1093/jas/skab063

[125] Gilani A, Kermanshahi H, Gholizadeh M, Golian A. Agricultural water management through magnetization of irrigation and drinking water: A review. Journal of Aridland Agriculture 2017; 3: 23-7.
https://doi.org/10.25081/jaa.2017.v3.3353

[126] Ebrahim SA, Azab AE. Biological effects of magnetic water on human and animals. Biomed Sci 2017; 3(4): 78.
https://doi.org/10.11648/j.bs.20170304.12

[127] El-Ghany A. Magnetized water as an alternative strategy to improve the poultry production system. Iranian Journal of Veterinary Science and Technology 2022; 14(3): 1-0.

[128] Gholizadeh M, Arabshahi H, Saeidi MR, Mahdavi B. The effect of magnetic water on growth and quality improvement of poultry. Middle-East Journal of Scientific Research 2008; 3(3): 140-4.

[129] Al-Mufarrej S, Al-Batshan HA, Shalaby MI, Shafey TM. The effects of magnetically treated water on the performance and immune system of broiler chickens. International Journal of Poultry Science 2005; 4(2): 96-102.
https://doi.org/10.3923/ijps.2005.96.102

[130] Kim HS, Adiyanto O, Byun JY, Chung SW, Kwon SG, Park JM, Kim JS, Choi WS. The Effectiveness of Magnetic Water Treatment to Improve Milk Fat and Milk Production of Dairy Cows. International Information Institute (Tokyo). Information 2016; 19(10A): 4463.

[131] Khudiar K, Ali AM. Effect of magnetic water on some physiological aspects of adult male rabbits. In Proceeding of the Eleventh Veterinary Scientific Conference 2012; 120: 126
https://doi.org/10.30539/iraqijvm.v36i0E.405

[132] Yacout MH, Hassan AA, Khalel MS, Shwerab AM, Abdel-Gawad EI, Abdel-Kader YI. Effect of magnetic water on the performance of lactating goats. J. Dairy Vet. Anim. Res 2015; 2(5): 00048.
https://doi.org/10.15406/jdvar.2015.02.00048

[133] AST International. Hunza Water link. http://www.astinternational.com/hydrationwaterresearch.html

[134] Abbas H, Khan MZ, Begum F, Raut N, Gurung S. Physicochemical properties of irrigation water in western Himalayas, Pakistan. Water Supply 2020; 20(8): 3368-79.
https://doi.org/10.2166/ws.2020.221

[135] Ali A, Hussain K. Drinking water Quality analysis of Hunza-Nagar Gilgit.

[136] Khalid N, Ahmad A, Khalid S, Ahmed A, Irfan M. Mineral composition and health functionality of Zamzam water: A review. International journal of food properties 2014; 17(3): 661-77.
https://doi.org/10.1080/10942912.2012.660721

[137] Al Doghaither HA, Al-Ghafari AB, Rahimulddin SA, Al Zahrani SM, Omar AS, Omar UM. Evaluation of the potential anticancer activity of zamzam water in human colon cancer cell line. Cancer Oncol. Res 2016; 4(3): 33-41.
https://doi.org/10.13189/cor.2016.040301

[138] Boshra AY, Mariod AA, Massad FA, Abdalrhman EM, Abbas SM, Hassan AA, Mahamedan MM, Elatta NM, Masaad10 HK, Hamid12 AM, Fadlalmola13 HA. Composition, hydrology, and health benefits of Zamzam water. Revista Bionatura 2021; 6(4): 2326-30.
https://doi.org/10.21931/RB/2021.06.04.30

[139] Abuelhaija Y, Mustafa A, Al-Bataineh HA, Alzaqh M, Mustafa A, Bawa'neh F, Alomari M, Alkhader A. A systematic review of the neurological effects of Zamzam water. World Journal of Advanced Research and Reviews 2023; 18(3): 1348-53.
https://doi.org/10.30574/wjarr.2023.18.3.1255

[140] Ignatov I, Mosin O. Studying the Composition and Properties of Mountain and Melt Water of Bulgaria and Russia as Factors of Longevity. Journal of Medicine, Physiology and Biophysics 2016; 22: 20-34.

[141] Ignatov I. Studying of the factors of longevity in Smolyan municipality, Rhodope mountains, Bulgaria as area of oxidant/antioxidant balance. Bulgarian Journal of Public Health 2018; 10(1): 34-50.

[142] Ignatov I, Gencheva N, Marinov T, Yaneva I, Angelcheva M, Dinkov G, Angushev I. Electrochemically activated water catholyte for the activation of hydrogen ions and atp for sport's shape and recovery. Journal of Advances in Medicine and Medical Research 2020: 112-9.
https://doi.org/10.9734/jammr/2020/v32i430407

[143] Ignatov I, Mosin O. Water: Solid and Liquid Phases. Nano Structures in the Water in Solid and Liquid Phases. structure 2015; 9.

[144] Ignatov I, Mosin O. Physical-Chemical Properties of Mountain Water from Bulgaria after Exposure to a Fullerene Containing Mineral Shungite and Aluminosilicate Mineral Zeolite. European Reviews of Chemical Research 2015; 5(3): 166-79.
https://doi.org/10.13187/ercr.2015.5.166

[145] Ignatov I, Popova TP, Petrova T, Ignatov AI. Physicochemical Parameters and *in vivo* antimicrobial effects on water filtrated with nano-structured carbonaceous Shungite. Journal of Chemical Technology & Metallurgy 2022; 57(5).

[146] Ignatov I, Mosin O. Mathematical models describing water clusters as interaction among water molecules. distributions of energies of hydrogen bonds. Journal of Medicine, Physiology and Biophysics 2014; 3: 48-70. https://doi.org/10.13187/ejnr.2014.3.141

[147] Ignatov I, Mosin O. Structural Models of Water and Structuring of Nano-clusters Regarding the Energies of Hydrogen Bonds. Journal of Medicine, Physiology and Biophysics 2015; 19: 47-65.

[148] Ignatov I, Mosin O. New Evidence of the Existence of Associative Elements of Water (Clusters). Journal of Medicine, Physiology and Biophysics 2016; 25: 64-82.

[149] Ignatov I, Mosin OV. Hydrogen Bonds among Molecules in Liquid and Solid State of Water. Modifications of Ice Crystals. Journal of Health, Medicine and Nursing 2014; 5: 56-79.

[150] Lorenzo I, Serra-Prat M, Yébenes JC. The role of water homeostasis in muscle function and frailty: a review. Nutrients 2019 Aug; 11(8): 1857. https://doi.org/10.3390/nu11081857

[151] Kerch G. Role of changes in state of bound water and tissue stiffness in development of age-related diseases. Polymers 2020; 12(6): 1362. https://doi.org/10.3390/polym12061362

[152] Kerch G. Distribution of tightly and loosely bound water in biological macromolecules and age-related diseases. International journal of biological macromolecules 2018 Oct 15; 118: 1310-8. https://doi.org/10.1016/j.ijbiomac.2018.06.187

[153] Szigeti GP, Szasz O, Hegyi G. Connections between Warburg's and Szentgyorgyi's Approach about the Causes of Cancer. Journal of Neoplasm 2017; 1(2-8): 1-3.

[154] Ignatov I, Toshkova R, Gluhchev G, Drossinakis C. Results of Blood Serum from Cancer Treated Hamsters with Infrared Thermal Field and Electromagnetic Fields. Journal of Health, Medicine and Nursing 2019; 58: 101-12.

[155] Pollack GH The Fourth Phase of Water. Beyond Solid, Liquid, and Vapor. Ebner and Sons Publishers: Seattle, WA, USA 2013.

[156] Toshkova R, Ignatov I, Zvetkova E, Gluhchev G. Beneficial Effects of Drossinakis Bio-influence (With Infrared Thermal and Electromagnetic Fields) on the Development of Experimental Graffi Myeloid Tumors in Hamsters. Hematological Studies. Journal of Medicine, Physiology and Biophysics 2019; 54: 13-7.

[157] Hwang SG, Hong JK, Sharma A, Pollack GH, Bahng G. Exclusion zone and heterogeneous water structure at ambient temperature. PLoS One 2018; 13(4): e0195057. https://doi.org/10.1371/journal.pone.0195057

[158] Hwang SG, Lee HS, Lee BC, Bahng G. Effect of antioxidant water on the bioactivities of cells. International journal of cell biology 2017; 2017.

https://doi.org/10.1155/2017/1917239

[159] Mojica KT, Massari JR, Rodriguez JR, Olalde J, Berdiel M, Gonzalez MJ. Structured Water and Cancer: Orthomolecular Hydration Therapy. Journal of Cancer Research Updates 2023; 12: 5-9. https://doi.org/10.30683/1929-2279.2023.12.2

[160] Mayrovitz HN. Measuring Breast Cancer-Related Lymphedema. Exon Publications 2022: 63-82. https://doi.org/10.36255/exon-publications-breast-cancer-lymphedema

[161] Ikaga R, Namekata I, Kotiadis VN, Ogawa H, Duchen MR, Tanaka H, Iida-Tanaka N. Knockdown of aquaporin-8 induces mitochondrial dysfunction in 3T3-L1 cells. Biochemistry and biophysics reports 2015; 4: 187-95. https://doi.org/10.1016/j.bbrep.2015.09.009

[162] Kozumi T, Kitagawa Y. Water structure changes induced by ceramics can be detected by increased permeability through aquaporin. Biochemistry and biophysics reports 2016; 5: 353-8. https://doi.org/10.1016/j.bbrep.2016.01.002

[163] Ali AF, Cosemi E, Kamel S, Mohammed S, Elhefnawy M, Farid L, Shaker S. Miracle of Zamzam water: the effect on human endometrial aquaporin. IWTC 2009; 13: 1515-20.

[164] Mayrovitz HN. Measuring Breast Cancer-Related Lymphedema. Exon Publications 2022: 63-82. https://doi.org/10.36255/exon-publications-breast-cancer-lymphedema

[165] Broman ME, Vincent JL, Ronco C, Hansson F, Bell M. The relationship between heart rate and body temperature in critically Ill patients. Critical Care Medicine 2021; 49(3): e327-31. https://doi.org/10.1097/CCM.0000000000004807

[166] Heal C, Harvey A, Brown S, Rowland AG, Roland D. The association between temperature, heart rate, and respiratory rate in children aged under 16 years attending urgent and emergency care settings. European Journal of Emergency Medicine 2022 Dec; 29(6): 413. https://doi.org/10.1097/MEJ.0000000000000951

[167] Ruetenik A, Barrientos A. Dietary restriction, mitochondrial function and aging: from yeast to humans. Biochimica et Biophysica Acta (BBA)-Bioenergetics 2015; 1847(11): 1434-47. https://doi.org/10.1016/j.bbabio.2015.05.005

[168] Wickens AP. Ageing and the free radical theory. Respiration physiology 2001 Nov 15; 128(3): 379-91. https://doi.org/10.1016/S0034-5687(01)00313-9

[169] Speakman JR. Body size, energy metabolism and lifespan. Journal of Experimental Biology 2005; 208(9): 1717-30. https://doi.org/10.1242/jeb.01556

[170] Speakman JR, Selman C, McLaren JS, Harper EJ. Living fast, dying when? The link between aging and energetics. The Journal of nutrition 2002; 132(6): 1583S-97S. https://doi.org/10.1093/jn/132.6.1583S

[171] Stessman J, Jacobs JM, Stessman□Lande I, Gilon D, Leibowitz D. Aging, resting pulse rate, and longevity. Journal of the American Geriatrics Society 2013; 61(1): 40-5. https://doi.org/10.1111/jgs.12060

[172] Custodis F, Reil JC, Laufs U, Böhm M. Heart rate: a global target for cardiovascular disease and therapy along the cardiovascular disease continuum. Journal of cardiology 2013; 62(3): 183-7 https://doi.org/10.1016/j.jjcc.2013.02.018

[173] Tverdal A, Hjellvik V, Selmer R. Heart rate and mortality from cardiovascular causes: a 12 year follow-up study of 379 843 men and women aged 40–45 years. European heart journal 2008; 29(22): 2772-81. https://doi.org/10.1093/eurheartj/ehn435

[174] Jensen MT. Resting heart rate and relation to disease and longevity: past, present and future. Scandinavian journal of clinical and laboratory investigation 2019; 79(1-2): 108-16. https://doi.org/10.1080/00365513.2019.1566567

[175] Jensen MT, Marott JL, Allin KH, Nordestgaard BG, Jensen GB. Resting heart rate is associated with cardiovascular and all-cause mortality after adjusting for inflammatory markers: the Copenhagen City Heart Study. European journal of preventive cardiology 2012; 19(1): 102-8. https://doi.org/10.1177/1741826710394274

[176] Woodward M, Webster R, Murakami Y, Barzi F, Lam TH, Fang X, Suh I, Batty GD, Huxley R, Rodgers A. The association between resting heart rate, cardiovascular disease and mortality: evidence from 112,680 men and women in 12 cohorts. European journal of preventive cardiology 2014; 21(6): 719-26. https://doi.org/10.1177/2047487312452501

[177] Quer G, Gouda P, Galarnyk M, Topol EJ, Steinhubl SR. Inter-and intraindividual variability in daily resting heart rate

and its associations with age, sex, sleep, BMI, and time of year: Retrospective, longitudinal cohort study of 92,457 adults. Plos one 2020 Feb 5; 15(2): e0227709. https://doi.org/10.1371/journal.pone.0227709

[178] Cheţan M. Body composition monitoring through bioelectrical impedance analysis. In2015 9th International Symposium on Advanced Topics in Electrical Engineering (ATEE) 2015 May 7 (pp. 265-268). IEEE. https://doi.org/10.1109/ATEE.2015.7133826

[179] Hamilton-James K, Collet TH, Pichard C, Genton L, Dupertuis YM. Precision and accuracy of bioelectrical impedance analysis devices in supine versus standing position with or without retractable handle in Caucasian subjects. Clinical Nutrition ESPEN 2021; 45: 267-74. https://doi.org/10.1016/j.clnesp.2021.08.010

[180] Seward C, Skolny M, Brunelle C, Asdourian M, Salama L, Taghian AG. A comprehensive review of bioimpedance spectroscopy as a diagnostic tool for the detection and measurement of breast cancer-related lymphedema. Journal of surgical oncology 2016; 114(5): 537-42. https://doi.org/10.1002/jso.24365

[181] Yu Z, Liu N, Wang L, Chen J, Han L, Sun D. Assessment of skin properties in chronic lymphedema: measurement of skin stiffness, percentage water content, and transepidermal water loss. Lymphatic Research and Biology 2020; 18(3): 212-8. https://doi.org/10.1089/lrb.2018.0066

[182] Mayrovitz HN, Weingrad DN, Brlit F, Lopez LB, Desfor R. Tissue dielectric constant (TDC) as an index of localized arm skin water: differences between measuring probes and genders. Lymphology 2015; 48(1): 15-23.

[183] Lahtinen T, Seppälä J, Viren T, Johansson K. Experimental and analytical comparisons of tissue dielectric constant (TDC) and bioimpedance spectroscopy (BIS) in assessment of early arm lymphedema in breast cancer patients after axillary surgery and radiotherapy. Lymphatic research and biology 2015 Sep 1; 13(3): 176-85. https://doi.org/10.1089/lrb.2015.0019

[184] Pollack GH Cell electrical properties: reconsidering the origin of the electrical potential Cell Biol Int 2015; 39(3): 237-342. ISSN 1065-6995 doi: 10.1002/cbin.10382. https://doi.org/10.1002/cbin.10382

[185] Pollack, G. H., X. Figueroa, and Q. Zhao 2009. Molecules, water, and radiant energy: new clues for the origin of life International journal of molecular sciences 10(4): 1419-1429. https://doi.org/10.3390/ijms10041419

[186] Pollack GH Water, energy and life: fresh views from the water's edge International journal of design & nature and ecodynamics: a transdisciplinary journal relating to nature, science and the humanities 2010; 5(1): 27. https://doi.org/10.2495/DNE-V5-N1-27-29

[187] Hwang SG, Hong JK, Sharma A, Pollack GH, Bahng G. Exclusion zone and heterogeneous water structure at ambient temperature PLoS One 2018; 13(4). https://doi.org/10.1371/journal.pone.0195057

[188] Kundacina N, Shi M, Pollack GH. Effect of local and general anesthetics on interfacial water PLoS One 2016; 11(4): e0152127. https://doi.org/10.1371/journal.pone.0152127

[189] Sommer AP. Mitochondrial cytochrome c oxidase is not the primary acceptor for near infrared light—it is mitochondrial bound water: the principles of low-level light therapy. Annals of Translational Medicine 2019; 7(Suppl 1). https://doi.org/10.21037/atm.2019.01.43

[190] Sommer AP, Schemmer P, Pavláth AE, Försterling HD, Mester ÁR, Trelles MA. Quantum biology in low level light therapy: death of a dogma. Annals of Translational Medicine 2020; 8(7). https://doi.org/10.21037/atm.2020.03.159

[191] Ravera S, Colombo E, Pasquale C, Benedicenti S, Solimei L, Signore A, Amaroli A. Mitochondrial bioenergetic, photobiomodulation and trigeminal branches nerve damage, what's the connection? A Review. International Journal of Molecular Sciences 2021; 22(9): 4347. https://doi.org/10.3390/ijms22094347

[192] Passarella S, Casamassima E, Molinari S, Pastore D, Quagliariello E, Catalano IM, Cingolani A. Increase of proton electrochemical potential and ATP synthesis in rat liver mitochondria irradiated *in vitro* by helium□neon laser. FEBS letters 1984; 175(1): 95-9. https://doi.org/10.1016/0014-5793(84)80577-3

[193] Alexandratou E, Yova D, Handris P, Kletsas D, Loukas S. Human fibroblast alterations induced by low power laser irradiation at the single cell level using confocal microscopy. Photochemical & Photobiological Sciences 2002; 1: 547-52. https://doi.org/10.1039/b110213n

[194] Hu WP, Wang JJ, Yu CL, Lan CC, Chen GS, Yu HS. Helium–neon laser irradiation stimulates cell proliferation through photostimulatory effects in mitochondria. Journal of Investigative Dermatology 2007; 127(8): 2048-57. https://doi.org/10.1038/sj.jid.5700826

[195] Yu W, Naim JO, McGowan M, Ippolito K, Lanzafame RJ. Photomodulation of oxidative metabolism and electron chain enzymes in rat liver mitochondria. Photochemistry and photobiology 1997; 66(6): 866-71. https://doi.org/10.1111/j.1751-1097.1997.tb03239.x

[196] Yang L, Youngblood H, Wu C, Zhang Q. Mitochondria as a target for neuroprotection: role of methylene blue and photobiomodulation. Translational neurodegeneration 2020; 9: 1-22. https://doi.org/10.1186/s40035-020-00197-z

[197] Konovalov AI, Ryzhkina IS, Murtazina LI, Kiseleva YV. Forming the nanosized molecular assemblies (nanoassociates) is a key to understand the properties of highly diluted aqueous solutions. Biophysics 2014; 59: 341-6. https://doi.org/10.1134/S0006350914030142

[198] Sidorenko GN, Konovalov AI, Laptev BI, Ivanova TG, Gorlenko NP, Antoshkin LV, Ryzhkina IS. On the role of water structure in the mechanism of complex action of the magnetic field, natural healing factors and highly diluted solutions. Bull. New Med. Technol 2017: 71-81.

[199] Chang KT, Weng CI The effect of an external magnetic field on the structure of liquid water using molecular dynamics simulation. Journal of Applied Physics 2006; 100(4): 043917 https://doi.org/10.1063/1.2335971

[200] Cai R, Yang H, He J, Zhu W. The effects of magnetic fields on water molecular hydrogen bonds. Journal of molecular structure 2009; 938(1-3): 15-9. https://doi.org/10.1016/j.molstruc.2009.08.037

[201] Pang X, Deng B. Investigation of changes in properties of water under the action of a magnetic field. Science in China Series G: Physics, Mechanics and Astronomy 2008; 51(11): 1621-32. https://doi.org/10.1007/s11433-008-0182-7

[202] Jung DH, Yang JH, Jhon MS. The effect of an external electric field on the structure of liquid water using molecular dynamics simulations. Chemical physics 1999; 244(2-3): 331-7. https://doi.org/10.1016/S0301-0104(99)00119-6

[203] Ghauri SA, Ansari MS. Increase of water viscosity under the influence of magnetic field. Journal of Applied Physics 2006; 100(6). https://doi.org/10.1063/1.2347702

[204] Shalatonin V, Pollack GH. Magnetic fields induce exclusion zones in water. Plos one 2022; 17(5): e0268747. https://doi.org/10.1371/journal.pone.0268747

[205] Mohamed HA, Hanafy MS. Static Magnetic Field With 2 mT Strength Changes the Structure of Water Molecules and

Exhibits Remarkable Increases in the Yield of *Phaseolus vulgaris*. Plant Archives (09725210) 2021; 21(1).
https://doi.org/10.51470/PLANTARCHIVES.2021.v21.no1.238

[206] Chen B, Ivanov I, Klein ML, Parrinello M. Hydrogen bonding in water. Physical Review Letters 2003; 91(21): 215503.
https://doi.org/10.1103/PhysRevLett.91.215503

[207] Szcześ A, Chibowski E, Hołysz L, Rafalski P. Effects of static magnetic field on water at kinetic condition Chemical Engineering and Processing: Process Intensification 2011 Jan 1; 50(1): 124-7.
https://doi.org/10.1016/j.cep.2010.12.005

[208] Lagnado A, Leslie J, Ruchaud‐Sparagano MH, Victorelli S, Hirsova P, Ogrodnik M, Collins AL, Vizioli MG, Habiballa L, Saretzki G, Evans SA. Neutrophils induce paracrine telomere dysfunction and senescence in ROS‐dependent manner. The EMBO journal 2021; 40(9): e106048.
https://doi.org/10.15252/embj.2020106048

[209] Forman HJ, Torres M. Reactive oxygen species and cell signaling: respiratory burst in macrophage signaling. American journal of respiratory and critical care medicine 2002; 166(suppl 1): S4-8.
https://doi.org/10.1164/rccm.2206007

[210] Voeikov VL. Reactive oxygen species—(ROS) pathogens or sources of vital energy? Part 1. ROS in normal and pathologic physiology of living systems. Journal of Alternative & Complementary Medicine 2006; 12(2): 111-8.
https://doi.org/10.1089/acm.2006.12.111

[211] Voeikov VL. Reactive oxygen species (ROS): pathogens or sources of vital energy? Part 2. Bioenergetic and bioinformational functions of ROS. Journal of Alternative & Complementary Medicine 2006; 12(3): 265-70.
https://doi.org/10.1089/acm.2006.12.265

[212] Voeikov VL. Biological oxidation: over a century of hardship for the concept of active oxygen. Cell Mol Biol 2005; 51: 663-75.

[213] Checconi P, De Angelis M, Marcocci ME, Fraternale A, Magnani M, Palamara AT, Nencioni L. Redox-modulating agents in the treatment of viral infections. International Journal of Molecular Sciences 2020; 21(11): 4084.
https://doi.org/10.3390/ijms21114084

[214] Khomich OA, Kochetkov SN, Bartosch B, Ivanov AV. Redox biology of respiratory viral infections. Viruses 2018; 10(8): 392.
https://doi.org/10.3390/v10080392

[215] Fraternale A, Zara C, De Angelis M, Nencioni L, Palamara AT, Retini M, Di Mambro T, Magnani M, Crinelli R. Intracellular redox-modulated pathways as targets for effective approaches in the treatment of viral infection. International Journal of Molecular Sciences 2021; 22(7): 3603.
https://doi.org/10.3390/ijms22073603

[216] Shalatonin V. Water-SARS-CoV-2 interaction-based mechanism inhibiting virus attachment to host cells. https://chemrxiv.org/engage/api-gateway/chemrxiv/assets/orp/resource/item/60c753384c89192fc4ad429a/original/water-sars-co-v-2-interaction-based-mechanism-inhibiting-virus-attachment-to-host-cells.pdf.

[217] Messori C. A biophysical approach to SARS-CoV-2 pathogenicity. Open Access Library Journal 2021; 8(12): 1-35.
https://doi.org/10.4236/oalib.1108183

[218] Chen CS, Chung WJ, Hsu IC, Wu CM, Chin WC. Force field measurements within the exclusion zone of water. Journal of biological physics 2012; 38: 113-20.
https://doi.org/10.1007/s10867-011-9237-5

[219] Cheng Y, Moraru CI. Long-range interactions keep bacterial cells from liquid-solid interfaces: Evidence of a bacteria exclusion zone near Nafion surfaces and possible implications for bacterial attachment. Colloids and Surfaces B: Biointerfaces 2018; 162: 16-24.
https://doi.org/10.1016/j.colsurfb.2017.11.016

[220] Kowacz M, Pollack GH. Propolis-induced exclusion of colloids: Possible new mechanism of biological action. Colloid and interface science communications 2020; 38: 100307.
https://doi.org/10.1016/j.colcom.2020.100307