WATER
A MULTIDISCIPLINARY
RESEARCH JOURNAL

Self-Organization Against Environmental Stressors, Evolved Elaborately Through Spontaneous Turbulent Dilutions, Led Biological Evolution: Chaos/Complexity and Quantum Coherence-Based Novel Theory

Upadhyay RP[1]*

[1]Simillimum Welfare Society, Nainital/New Delhi, India

*Correspondence e-mail: upadhyayrp52@gmail.com

• Received: September 28, 2020
• Revised: May 31, 2021
• Re-revised: November 19, 2021
• Accepted: December 20, 2021
• Published: February 21, 2022

doi:10.14294/WATER.2021.3

Keywords: self-organization and emergence; environmental stressor; turbulent serial dilution; nanoparticle-exclusion zone shell; quantum coherence domain; morphogenetic field; biological evolution; autopoiesis; tissue engineering; regenerative medicine

Abstract

Evolutionary biologists are confused and divided, some even condemning their theories as just history or storytelling. They are confined to elaborative evolution while self-organization pervades biology. A quantum approach including self-organization and emergence as the physics of complex systems is essentially required, with water, a two-phase liquid, one phase of which is quantum coherent. These physical realities are instrumental for the evolution, even of the properties of an environmental stressor, through its turbulent serial dilution. Such dilution happens spontaneously in nature, and defying conventional wisdom, can cause even epigenetic and genomic effects. Electromagnetic potential and the phase can store information as biological agents. Homeopathy, incredibly, uses such dilutions as medicines. In this statistical, nondeterministic, and quantum mechanically elusive world, the real-life empirical observations of homeopathy are evidence of their biological effects. The proposed theory suggests that the environmental stressor is a more crucial driver of evolution than the organism or its genes, evolutionary products in themselves. Its four-dimensional geometrical template could evolve in the organism during its evolutionary history what it can now disturb in health or restore during sickness. Thus, directing self-organization through morphogenesis, such stressors turn-by-turn led the whole organism's evolution to adapt better. They gradually built up a critical state in the organism, followed by its rapid specification. Their random permutations led to biodiversity. Thus, this theory may cover evolution from its deep molecular interior, while contemporary theory covers its macroscopic exterior; these theories complement each other. This view finds an immediate test application in regenerative medicine and may lead to quantum medicine.

Introduction

Most evolutionary research has continued along traditional lines (Johnson and Lam, 2010). Self-organization should be placed alongside natural selection as a complementary mechanism of evolution (Johnson and Lam, 2010; Nicolis and Prigogine, 1977; Kauffman, 1993; Camazine *et al.*, 2001; Denton *et al.*, 2003; Kurakin, 2007; Newman *et al.*, 2006; Karsenti, 2008; Wills, 2009).

Evolution based on self-organization at the molecular level is different from evolution at the macroscopic level. Thus, a new synthesis is required for evolutionary theory (Kauffman, 1993; Kurakin, 2007; Wills, 2009). Besides incorporating genetics into natural selection, it also requires combining the physics of complex systems (Nicolis and Prigogine, 1977; Kauffman, 1993; Camazine *et al.*, 2001; Newman *et al.*, 2006; Karsenti, 2008).

There are myriad ways in which self-organization affects the evolutionary process (Johnson and Lam, 2010). Though environmental stress is recognized as an evolutionary force (Hoffmann and Hercus, 2000), the pos-

sible significant contributions of environmental stressors through their secondary actions (*i.e.*, the organism's reaction to them) has never been considered in evolutionary biology (Upadhyay, 2020).

On the "toxic" Earth, through self-organization, emergence, and natural selection, the organism could develop a mechanism to react to the environmental stressor as a biphasic dose-response, among other kinds of responses, where a low dose of the stressor is beneficial (Upadhyay, 2020). Such a phenomenon is called hormesis (Mattson and Calabrese, 2010a). The stressor's primary or pharmacological action causes a toxic effect, while the beneficial effect is due to its secondary action, *i.e.*, the organism's reaction to it. Its discoverer, Hugo Schulz (1887), took it as a putative explanation for homeopathy (Mattson and Calabrese, 2010b). Along with Rudolf Arndt, a psychiatrist/homeopath, Schulz proposed a law known as the Arndt-Schulz Law, suggesting that small doses of a toxic substance stimulate, moderate doses inhibit, and large doses kill. However, considering homeopathy unscientific, Schulz and his fundamental discovery were ignored in science (Calabrese and Baldwin, 2000). But, science has recently accepted hormesis as a natural phenomenon (Luckey, 1997; Stebbing, 1982; Stebbing, 1998; Calabrese, 2005; Mattson and Calabrese, 2010a).

When hormesis as a primary phenomenon could not deal with rising diseases as life became increasingly complex, it likely paved the way for an exclusively therapeutic phenomenon to evolve. This homeopathic phenomenon involved the law of similars, and turbulent serial dilution of the environmental stressor helped bring this about. Such dilutions happened spontaneously and were always a part of the environment (Upadhyay, 2020). The hypersensitivity in the organism is known to develop against a stressor by its ancestor's pre-exposure to the identical/similar stressor (Wiegant and Van Wijk, 2010; Van Wijk and Wiegant, 2010). This hypersensitivity can also develop if the organism suffers from a disease similar to that caused by exposure to this stressor (Hahnemann, 2013 edition, ch. 1). The organism gradually could become sensitive to the described dilutions even beyond Avogadro. These dilutions contain nanoparticle-exclusion zone (EZ) shells that can carry stressor-specific information (Upadhyay, 2020).

Spontaneous natural turbulent serial dilutions of environmental stressors are equivalent to their respective homeopathic medicines (Upadhyay, 2020). Incredibly, such a dilution can be much deeper in action than the stressor in concentration just below its toxic threshold. Conventionally, this amount of the stressor as the dose is considered best for hormesis to be visible. But its turbulent serial dilution can do more defying the conventional wisdom. Many independent research groups have reported that stressor diluted in this way can cause epigenetic and genomic effects (Şeker *et al.*, 2018; Olsen, 2017; Bigagli *et al.*, 2016; Saha *et al.*, 2015; Dei and Bernardini, 2015; Khuda-Bukhsh, 2014; Marzotto *et al.*, 2014; Olioso *et al.*, 2014; Olioso *et al.*, 2016; Das *et al.*, 2012; Preethi *et al.*, 2012; Sunila *et al.*, 2009).

Hormesis provides a short-term adaptation by causing enzymatic and a little transcriptional change (Sthijns *et al.*, 2016). Homeopathic phenomenon/homeopathy operates on epigenetic and genomic modifications causing long-term/permanent adaptation. Thus, dangerous environmental stressors could promote growth and turn into potent medicines to support life on the hostile Earth (Upadhyay, 2020).

Homeopathy is an adaptive stress-response therapy (Upadhyay, 2020; Bell *et al.*, 2015; Bell and Schwartz, 2013). The scientific understanding about it is increasing (Bellavite and Signorini, 2002; Bellavite *et al.*, 2014a; Bellavite *et al.*, 2014b; Bell, 2020a; Bell, 2020b; Upadhyay and Nayak, 2011), though three objections are often cited against it by skeptics who haven't any direct experience with it. These objections are as follows, along with a current scientific explanation about them:

1. Homeopathic medicine hardly contains the source-drug (stressor):

> A homeopathic medicine is a turbulent serial dilution of an environmental stressor even beyond Avogadro. Many scientists have suggested the ways in which it can possess stressor-specific information (Anagnostatos *et al.*, 1991; Anagnostatos, 1994; Smith, 1994; Del Giudice *et al.*, 1988; Upadhyay and Nayak, 2011; Upadhyay, 2018; Upadhyay, 2019). It contains nanoparticle-exclusion zone (Nanoparticle-EZ) shells that store this perceived information (Upadhyay and Nayak, 2011). During iteration, this information gets amplified, making homeopathic medicine more effective with its increasing dilution than its source substance (Upadhyay, 2017; Upadhyay, 2020). A recent study finds this explanation most plausible among the available ones (Ullman, 2021).

2. Homeopathic medicine's mechanism of action is ex-

plained by the use of the "vital force:"

> Science has discarded the vital force concept. However, the scientific understanding about the development of this concept is now increasing (Milgrom, 2020; Teixeira, 2020; Waisse and Bonamin, 2016; Teut, 2001). This concept has even become a "hot" subject in cell biology (Kirschner *et al.*, 2000). Here, the mystery of robust physiology and embryology among non-determinist statistical operations is compelling us to relook at this old concept to explore the science behind it.

3. Homeopathy performs poorly in randomized, placebo-controlled, double-blind clinical trials (Editorial, *The Lancet,* 2005; Linde *et al.*, 1997):

> Modern (*i.e.*, institutional) medicine has designed these trials to test the efficacy of its drugs. But homeopathy is a highly individualistic therapy, and such practices do not suit it (Milgrom, 2009; Milgrom, 2014; Bellavite *et al.*, 2006). These trials are not suitable for testing a hormetic agent's efficacy either, as the toxic threshold can vary from person to person (Calabrese *et al.*, 2013). However, some studies claim that they can be helpful in testing the efficacy of homeopathy, too, if care is taken for its specific features (Mathie *et al.*, 2018; Mathie *et al.*, 2017). Arguments have also been made that, through them, scientism has been allowed to creep into medicine as an unscientific pseudo-religious belief (Milgrom, 2021; Loughlin, 2021). Scientism in medicine can be a fatal error (Leggett, 1997).

The infamous "memory of water" controversy is linked with homeopathy (Pollack, 2013, ch. 2). However, the water memory effect is also observed in physics with magnetic field-exposed water. Such water is found beneficial economically in several applications like descaling pipes and boilers, reducing the corrosion rate of steel, enhancing water evaporation, and cement hydration (Colic and Morse, 1999; Coey and Cass, 2000; Otsuka and Ozeki, 2006; Upadhyay, 2017). In ecology, the water memory effect is visible as the impact of antecedent climate conditions on current vegetation productivity (Seddon *et al.*, 2016; Ogle *et al.*, 2015; Liu *et al.*, 2018).

Water (H_2O), as conventionally known, cannot remember its experience. However, recent developments in water science show that its exclusion zone (EZ) phase ($H_3O_2^-$) can have this ability (Web ref. 1). However, it would be a short memory because of EZ's molecular attrition. For a prolonged memory, the EZ would require a hydrophilic nanoparticle as a physical substrate to hold it in the form of interfacial water cover and be a partner in information storage (Upadhyay, 2017).

Quantum electrodynamics theoretically supports the observed existence of liquid water in two interchangeable phases: bulk water (H_2O) and quantum coherence water (Del Giudice *et al.*, 1988). Coherent interaction between the water electric dipoles and the ambient (vacuum) electromagnetic field generates the latter as the ordered structures in macroscopic domains (Del Giudice *et al.*, 1988). It has been identified with EZ water (Del Giudice *et al.*, 2010).

These macroscopic water coherence domains validate the presence of special biological water as long perceived by Szent-Gyorgyi (1956, 1957). It led to "the dawn of a real quantum biology" (De Ninno *et al.*, 2013). After Fröhlich's work (1968, 1970, 1975), "What remains indisputable is that the quantum dynamics that are undoubtedly taking place within living systems have been subject to 3.5 billion years of optimizing evolution. It is likely that, in that time, life has learned to manipulate quantum systems to its advantage in ways that we do not yet fully understand" (McFadden and Al-Khalili, 2018).

Quantum electrodynamics, which studies the interactions between electromagnetic fields and matter, is most suitable to understanding homeopathy (Manzalini and Galeazzi, 2019; Ho, 2014a; Ho, 2012, ch. 8; Smith, 2004; Tosi and Del Giudice, 2013). The size of a quantum coherence domain has been calculated to be around 100 nm (Ho, 2014b; Ho, 2014c). It matches the size of a nanoparticle–EZ shell (Upadhyay, 2017).

The direct action of a toxic substance on an organism is its primary or pharmacological action. Its secondary action is the organism's reaction to it. Homeopathic medicine is the best source of pure secondary action of an environmental stressor as the stressor's primary action is nil because it is physically absent or nearly absent. Thus, the two-century-long clinical observations of homeopathy are what the secondary action of environmental stressors can do biologically. Therefore, the unscientific homeopathy provides the scientific evidence of biological activity of the secondary action of the environmental stressor. The mystery lies in complexity science. It suggests "the laws of the whole cannot be deduced by digging deeper into the details" (Vicsek, 2002).

Further, the world and its affairs are not deterministic (Kirschner *et al.*, 2000). At nanoscale and below, even a precise measurement, say, of position is not possible. Thus, empirical knowledge and heuristics can suffice (Ball, 2008). Moreover, Brian Josephson (1992) suggests, "Nature is fundamentally elusive and may resist grasping by the methods of science. If we wish to come to terms with this resistance, then a shift in the direction of taking direct experience into account may be necessary for science's future complete development."

Thus, we may break the existing scientific impasse evolutionary biology faces by changing our attitude. The impasse is, as Katsnelson *et al.* (2018) noted, though the physical principles create hope to develop an evolutionary biological theory, confusion looms on how to proceed further. To break this impasse, the present author makes an evidence-based suggestion that environmental stressors, especially elaborately evolved ones for their properties through their turbulent serial dilutions, could subtly lead to life's evolution. This suggestion is based on self-organization, emergence, and elaboration in the physical framework of chaos/complexity and quantum field theory exploiting clinical observations of homeopathy. Thus, an entirely new theory of biological evolution is developed. This theory answers the open question Hoffmann and Hercus (2000) raised: to what extent has environmental stress contributed to evolution. Further, this theory complements contemporary evolutionary theory and hopefully compensates for its deficiencies. This work extends the previous contribution of the present author (Upadhyay, 2020), which suggested that the homeopathic phenomenon could provide a genetically deeper therapeutic buffer than hormesis against environmental stressors and, thus, be a vital factor in the evolution of life.

Self-Organization, Self-Assembly, and Evolution

Self-organization and self-assembly have been essential parts of evolution. One of the most fundamental and long-lasting problems in biology has been the origin of physical forms and their functions (Karsenti, 2008). The hype of genes and their linear sequencing in a genome has already flopped in explaining the phenotypes and their molecular, cellular, and organismal function (Kirschner *et al.*, 2000; Misteli, 2007). Instead, self-organization at the cell level is important and must be appreciated to explain genome organization and function principles. For the emerging new cell biology of genomes, it is a great challenge to overturn long-held dogmas (Misteli, 2007).

The philosopher Immanuel Kant (1724-1804) was perhaps the first one to define life as a "self-organized, self-reproducing" process (Karsenti, 2008). He visioned life as the emergence of functions by self-organization, where every part owes its existence and origin to that of the other parts. Thus, a complete living organ or organism emerges from the parts' properties and the whole (Karsenti, 2008). Kant suggested that a new kind of science, "self-organization and emergence," would be required to study how purpose and means are intricately connected (Karsenti, 2008; Van de Vijver, 2006).

Self-organization is a physicochemical phenomenon of great importance. A system kept off equilibrium can self-organize. It has been known for a long time. It was first discovered in chemistry and physics (Karsenti, 2008). Its observance in biology has brought living and non-living worlds closer after Friedrich Wohler first synthesized urea, an organic compound, in 1828 through inorganic reactions (Johnson and Lam, 2010). Thus, self-organization has become a "general concept capable of unifying the animate and inanimate world" (Keller, 2005).

Both self-assembly and self-organization describe pattern formation mechanisms. Their importance in biology has been increasingly appreciated (Halley and Winkler, 2008). Self-assembly is a non-dissipative structural order where no input of energy is required. Self-assembling systems like viruses and ribosomes are not resilient and adaptable (Kirschner *et al.*, 2000). On the other hand, self-organizing systems are highly dynamic, *i.e.*, adaptable. There is a constant flux of energy and material. Self-organization is a dissipative non-equilibrium order at macroscopic levels because of collective, nonlinear interactions between multiple microscopic components. The interplay between intrinsic and extrinsic factors induces this order. The extrinsic factor invariably interacts with any self-organizing order with its template (Halley and Winkler, 2008). As such, guided self-organization is possible (Prokopenko, 2009). Self-organized structures, being dissipative, invariably decay once energy input ceases (Halley and Winkler, 2008).

The self-organizing mechanisms are physical and, thus, unlikely to produce slow, incremental change. Therefore, natural selection should not have always built complexity step by step (Kauffman 1993; Denton *et al.*, 2003;

Karsenti, 2008); instead, it discovers complexity (Johnson and Lam, 2010). Thus, self-organization lies at the heart of the robustness and adaptability found in cells and organisms. Therefore, self-organization constitutes a fundamental basis for natural selection and evolution (Wedlich-Soldner and Betz, 2018).

Strong arguments support that natural selection does not cause evolution but is its consequence (Maturana and Varela, 1987; Kauffman, 1993; Varela, 1979). The concept of autopoiesis provides one such argument. Humberto Maturana and Francisco Varela developed the concept of autopoiesis (*i.e.*, self-producing) as a definition of a living being to offer a unifying vision for biology (Razeto-Barry, 2012). It is a cell-like pragmatic blueprint of life. It provides a conceptually clear definition of minimal life and links it logically "with related notions, such as self-organization, emergence, biological autonomy, auto-referentiality, and interactions with the environment" (Luisi, 2003).

Maturana and Varela (1987, pp. 46-47) said:

> The most striking feature of an autopoietic system is that it pulls itself up by its own bootstraps and becomes distinct from its environment through its own dynamics, in such a way that both things are inseparable.

Maturana and Varela developed their concept during the 1970-80s in the RNA world-view of self-replication and Darwinian evolution in the nucleic acid mechanisms era (Luisi, 2003). Consequently, it could not attract sufficient attention. Now, when new interest in experimental cellular models and system biology is increasing, and the importance of complexity theories is becoming more apparent, autopoiesis is getting a reappraisal (Luisi, 2003; Podgórski, 2010).

Autopoiesis takes evolution as a natural drift of structural couplings between the organism and the dynamic environment at the molecular level (Podgórski, 2010). This natural drift is determined primarily by the inner coherence and autonomy of the living organism (Luisi, 2003). It causes adaptation and diversification of species. The evolution it causes is not entirely random, but one that suits most to the inner structure of the autopoietic unit (Podgórski, 2010; Maturana and Mpodozis, 2000; Maturana and Varela, 1987). As this autopoietic unit or the living organism is mostly water, water must first be understood to study evolution.

Water: The Mysterious Elixir of Life

Albert Szent-Gyorgyi expressed his sentiment about water in his famous quote (Web ref. 2): "Water is life's matter and matrix, mother and medium." Thus, the role of water, the principal constituent of all living organisms, cannot be trivial in evolution. However, "No one really understands water. It's embarrassing to admit it, but the stuff that covers two-thirds of our planet is still a mystery. Worse, the more we look, the more the problems accumulate … it is too anomalous, too strange" (Ball, 2008).

Del Giudice and colleagues (2009) even questioned:

> Water is the most important constituent of all living organisms (70% of the total mass and 99% of all molecules). Other biomolecules, proteins, fats, sugars, vitamins, and salts, which are usually considered the only molecules playing a remarkable role in molecular biology, make up only 1% of the total. So, biological activity is assumed to involve 1% of all molecules only. What is the role of water then? Is it possible that 99% of all biomolecules are necessary only as a solvent whereas the "really essential" biomolecules enact all productive activity?

Though water is a universal solvent, strangely, it kicks out almost everything at a hydrophilic surface, even solutes from it (Chai and Pollack, 2010). Such strange water found at a hydrophilic surface was named exclusion zone (EZ). It is highly self-organized water, and Pollack (2013) suggested it as the fourth phase of water. Henniker (1949) reported finding a living organism's surfaces coated up to hundreds of water molecule diameters by layers of peculiar water exhibiting the properties of a "liquid ice." As the conventional water theory could not understand such liquid crystalline water, many scientists have been skeptical of it; but now several groups have independently verified its existence (Musa *et al.*, 2013; Bunkin *et al.*, 2013; Jabs and Rubik, 2014; Yakhno and Yakhno, 2018).

Can water have a memory of its past experiences? If yes, it cannot be for more than 50 femtoseconds for water (H_2O) we understand conventionally (Cowan *et al.*, 2005). However, water exposed to a magnetic field keeps this experience in "memory" for up to 200 hours (Coey and Cass, 2000). Water, as known conventionally, cannot be "magnetized." So, many scientists are not ready to accept several independent research groups' observations in favor of the magnetization of water. They think traces of magnetic impurities in water could be behind such statements.

The truth, however, lies somewhere else. Pure water really cannot be magnetized in a vacuum. It can be magnetized only after its exposure to oxygen. Oxygen is necessary for EZ water ($H_3O_2^-$) buildup as it is rich in oxygen. Thus, only aerated water gets affected by magnetic or electromagnetic fields, modifying its properties and functions (Colic and Morse, 1999). This water magnetization can be studied scientifically with reproducible results (Otsuka and Ozeki, 2006). Comparing physical properties like viscosity, surface tension, evaporation rate, refractive index, and contact angle of "magnetized" water with those of EZ water showed that they are similar (Upadhyay, 2017). Therefore, it is fair to infer that only the EZ phase part of water gets "magnetized" and keeps the experience of magnetic field exposure in memory up to the reported period of 200 hours. The applied magnetic field may also promote the EZ buildup in the water as the ambient electromagnetic field does.

In UV-visible spectroscopy, the water that went through vortexing shows an absorption peak at around 270 nm, otherwise not observed. This peak suggests the formation of EZ water (Pollack, 2013, p. 179). Homeopathic medicines also exhibit such a peak (Elia *et al.*, 2014). In homeopathy, one-third of the bottle must remain empty when giving violent strokes to the dilution (Kayne, 2006). Water mixed with air (oxygen) under pressure helps in EZ buildup. The negative charge acquired by substances moving against air also helps (Pollack, 2013, p. 180).

Interestingly, homeopathic medicines prepared under reduced atmospheric pressure were less effective (Fisher, 2010). Water also cannot be "magnetized" in the atmosphere of N_2 and CO_2 (Otsuka and Ozeki, 2006). Further, homeopathic medicines prepared in the atmosphere of N_2 were therapeutically ineffective (Fisher, 1991). Now, one can understand why all this happens.

Thus, while bulk water (H_2O) cannot keep something in "memory," its EZ phase is suitable to do so in the following way:

> The structural lattice is essentially fixed. Oxygen and hydrogen atoms lodge at fixed positions within the lattice, and if any one of those atoms could get modified, that would constitute information. Modification possibilities abound: oxygen atoms have five possible oxidation states: -2, -1, 0, +1, +2. Hence the potential for high-density information storage is extraordinary (Web ref. 1).

Interestingly, Szent-Györgyi (1957), as far back as the 1960s, observed that biologists could not distinguish between "animate" and "inanimate" substances because they neglected two matrices, namely water and electromagnetic fields without which these substances cannot perform any functions. Szent-Györgyi also noted that electrons are available on biological surfaces, and biology exploits their energy. He regarded the long-range ordering of water as a major pillar in the edifice of life. Gilbert Ling also thought similarly (Pollack, 2013, p. 34).

Ling (1962) observed that intracellular water is different than intercellular water. He negated the dominant view of living cells as fluid-filled vesicles and the cell membrane pump theories. Instead, he developed the concept of nano-protoplasm and proposed the association-induction (AI) hypothesis as the theory of cell physiology. Nano-protoplasm is taken as the "association" of auto-cooperative assemblies of molecules, atoms, ions, and electrons being "inductive" due to the presence of an electric charge on them. Ling (2007) described nano-protoplasm as the most basic unit of life. He was an intensely passionate advocate of the stacked dipole model of biological water (Pollack, 2013, p. 51). He observed that in the living state, all the major components exist in their closely associated low entropy state. While in the dead state, water and ions are largely liberated and live as free water and free ions, with a large entropy gain (Ling, 2012). Though neglected in the mainstream, the association-induction (AI) hypothesis is the most appropriate theory of cell physiology that "attempts to formally describe and unify essential aspects of living phenomena" (Bagatolli *et al.*, 2020). During the current boost in colloid and interface science, this theory becomes inevitable "to revisit central concepts of cellular biology *without brushing aside the evident colloidal nature of the cell*" (Bagatolli *et al.*, 2020).

Much of the water in a cell is very close to one or another hydrophilic surface, and as such, most biological water is in the EZ phase (Pollack, 2001). This phase of water does not allow the presence of solutes. What, then, is the role of EZ water in the organism, in which it comprises the largest part?

The first possible role of EZ water was in the origin of life (Pollack *et al.*, 2009). The second possible role was in making the biological system more complex. The EZ donates electrons that cause "slow water burning" or "water respiration," releasing free energy. This energy could convert carbon dioxide and nitrogen into organic compounds (Voeikov and Del Giudice, 2009). The third impor-

tant role of EZ water is probably in making "information" the possible leading player in biological activity/evolution over "matter" (Upadhyay, 2020).

Therefore, water must be further studied. As Ling (2003) suggested, this study should be with a clear-cut theory based on the laws of physics that could predict the long-range dynamic ordering of water molecules.

Water: Quantum Field Theory Explains Two Phases with Information Storage in Coherent Phase

Quantum field theory (QFT) is essential to explore the intrinsic properties of the universe. This theory suggests the interaction of two separate physical systems through a quantized field that extends to another. This theory successfully describes the interactions between particles, between particles and fields, and even between fields. This theory was first developed as quantum electrodynamics (QED) to study electromagnetic interactions, now a part of it. This theory has superseded quantum mechanics (QM) (Zee, 2010).

In quantum field theory, the difference between wave and particle mitigates as a particle is an excitation of the quantum field that fills all the space. Other differences such as substance and form, structure and function, and matter and information also vanish (Renati, 2020; Vitiello, 2001). Molecules themselves become ordered electromagnetic structures (Bischof and Del Giudice, 2013; Cosic, 1994; Cosic, 1997).

Dicke (1954, 1964) suggested that if the distance between two emitters is smaller than the wavelength of the light emitted, emission happens cooperatively, and the field between the emitters is coherent. Experiments have fully verified this idea (Crubellier *et al.*, 1985). His additional suggestion of forming "electromagnetic cavities" in living matter is outstanding, as it helps to understand biomolecular interaction dynamics involved with living organisms (Li, 1992). Coherence causes self-organization (Li, 1994) and bridges micro- and macro systems (Li, 1995).

Fröhlich (1968, 1970) proposed that quantum coherence, *i.e.*, matter coupled with electromagnetic fields, plays a vital role in biological systems. Quantum coherence is the only known tool of physical phenomena that provides long-range, *i.e.*, macroscopic, correlations out of the microscopic dynamics of elementary components (Vitiello, 2012). Such microscopic quantum dynamics give rise to macroscopic dynamic properties, such as growth/formation, morphogenesis, bioenergetics, organization, and autopoiesis (Renati, 2020).

Del Giudice, Preparata, and Vitiello (1988) developed quantum field theory for liquid water as soft condensed matter. It suggests that interaction between the vacuum electromagnetic field and liquid water induces coherent excitations. It tunes water molecules' fluctuations, giving rise to large aggregates of the mesoscopic size where all molecules oscillate in phase with a self-trapped electromagnetic field. These aggregates are called coherent domains (Preparata, 1995). Coherent means all the constituents of the ensemble are fluctuating as oscillators in unison at well-defined frequencies. Such domains are present in liquid water, making it a two-phase liquid agreeing with its vibration spectra. However, the two phases of liquid water are interchangeable. They produce a flickering landscape as if liquid water exists only in one phase, *i.e.*, ordinary water (Bischof and Del Giudice, 2013).

Ordinary phase water is based on short-range electrostatic forces. In contrast, the coherent phase water is based on long-range electromagnetic forces and identifies with Pollack's EZ water. Zheng *et al.* (2006) found the temperature of coherent, *i.e.*, well-organized, water lower than that of less organized bulk water with which it was in contact. At low temperatures ($T \leq 200$ K), the whole of the liquid water becomes coherent and thus has only one phase (Buzzacchi *et al.*, 2002).

On a hydrophilic surface, such domains can enjoy a prolonged life as the energy gap for their thermal disruption is high enough to overcome at standard temperature and pressure. This high energy gap is due to the attraction of water molecules to the hydrophilic surface. Coherent water expels everything, even a solute molecule, out of it because any such foreign material cannot resonate with the ensemble. Thus, solutes dissolve exclusively into the non-coherent fraction of water (Ho, 2014a; Bischof and Del Giudice, 2013).

The electromagnetic field plays an essential role in matter formation and its properties. The matter can be both inanimate and animate. Complex systems, such as ecosystems, comprise them both. The electromagnetic field keeps the long-range, many-body correlation among the components. In general, the electromagnetic field is the primary tool of information storage and transfer in the living processes, as it is in modern technologies (Brizhik,

2011). It is a long-range messenger (Brizhik *et al.*, 2011; Brizhik *et al.*, 2009a) and behind the self-organization of an ecosystem (Brizhik *et al.*, 2009b). The electromagnetic potential whose space-time derivatives give rise to the electromagnetic fields is sufficient on its own to store information. It remains present even in the absence of electromagnetic fields. It makes living organisms highly energy-saving as the production of the electromagnetic field demands energy. Thus, the physical variables responsible for correlation and biocommunication are not the energy but the electromagnetic field/potential and the phase of the system (Bischof and Del Giudice, 2013; Brizhik *et al.*, 2009a; Smith, 1994; Trukhan and Anosov, 2007).

A quantum coherence domain oscillates with its natural frequency. As an ensemble, its components communicate with each other via the phase of their fluctuations, including fluctuations of the quantum vacuum. Thus, the quantum vacuum plays a role in spreading information among components (Zeiger and Bischof, 1998). A quantum coherence domain collects energy from the environment. Still, it lowers its entropy by keeping most of its water molecules in the excited state at 12.06 eV, just below their ionization threshold at 12.60 eV, in the coherent oscillations. This lowering entropy makes the coherence domain an electromagnetic cavity that traps electromagnetic fields in a well-defined frequency (Bischof and Del Giudice, 2013). Thus, this domain can store electromagnetic signals that account for the so-called "memory of water" while it lasts (Ho, 2014a).

A coherence domain as an electromagnetic cavity cannot radiate energy (Bischof and Del Giudice, 2013). Nevertheless, it becomes a ready source of free electrons to carry out redox reactions, as Szent-Gyorgyi (1956, 1957) perceived long ago with biological water (Bischof and Del Giudice, 2013). A coherence domain attracts the same/similar frequency biomolecules/nonaqueous molecules to resonate outside its surface. It supplies energy to them to carry out the required biochemical reactions. It also absorbs energy released in these reactions. This energy absorption changes the oscillation frequency of the electromagnetic fields trapped in it and thus its phase, changing consequently the molecular species that now get attracted. In this way, a feedback-based biochemical chain reaction is developed by these non-diffusive dynamics (Bischof and Del Giudice, 2013; Brizhik *et al.*, 2011).

Thus, the prevalent biochemical signal transmission model can be essential but insufficient. For example, bioreceptors provide a static and mechanical approach suggesting a biological response to being strictly local and linear, *i.e.*, proportional to the stimulus. But, often, it is not true, and hence, a biophysical complement is required as described above (Bischof and Del Giudice, 2013).

Electromagnetism provides a long-range field. This field may be responsible for recognizing macromolecules, such as enzyme and substrate, DNA and RNA, antigen and antibody, and different types of cells (Bischof and Del Giudice, 2013; Presman, 1970; Rowlands, 1988; Paul, 1983). Cosic (1994) observed that molecules recognize their targets and vice versa by electromagnetic resonance. Further, macromolecules sharing the same function share a common vibrational frequency (Ho, 2007).

Collini *et al.* (2010) carried out spectroscopic measurements on light-harvesting proteins isolated from marine cryptophyte algae. Their study revealed that distant molecules within the photosynthetic proteins were 'wired' together by quantum coherence for more efficient light harvesting. This study, published in *Nature*, confirms experimentally that long-range quantum coherence sustains between molecules in complex biological systems, even at ambient temperatures.

Extreme Sensitivity of Coherent Water to the Environment

Circadian rhythm is present in nearly all life forms. It has been attributed to some genes and feedback loops. The scientists involved were honored with the 2017 Nobel Prize in Physiology or Medicine (Huang, 2018). However, what is behind these genes and feedback loops that accounts for their existence? It is the spin of the Earth in front of the Sun, *i.e.*, electromagnetism affecting coherent water and influencing evolution accordingly.

After a prolonged study, Piccardi (1946, 1956, 1962) was the first to demonstrate conclusively that cosmic or environmental events significantly change the physical properties of molecular systems suspended in liquid water. For example, changes in precipitation rates of colloids follow the time evolution of sunspots or other climatic events.

Vegetable leaves and algae, which were biologically irritated through trituration to enhance their living dynamics, affected the physical properties of liquid water to which they were added. This water was found more

responsive to the environment than untreated water (Tedeschi, 2010).

Voeikov and colleagues (Gurfinkel *et al.*, 2001; Voeikov *et al.*, 2010) detected drastic changes in photon emission from activated bicarbonate solutions coinciding with solar and lunar eclipses and seismic activity occurring even very far away. These solutions contained suspended particles and thus were like colloidal solutions. The significance of this observation is high as carbonates may be considered universal regulators of metabolism (Brizhik *et al.*, 2011).

In the above experiments, the suspended particles in water were hydrophilic. Thus, the most significant aspect of these experiments was the obvious presence of the EZ, *i.e.*, coherent water on the surface of the suspended particles. A coupling between the electromagnetic vector potentials, produced by the water coherence domains and those originating in the electromagnetic radiation produced by sunspots, cosmic events, terrestrial crust movements, or other atmospheric events, is the cause of the observed extreme sensitivity (Del Giudice *et al.*, 2010). Thus, coherence domains are the natural receptors of the extra weak signals coming from afar (Brizhik *et al.*, 2011). They can convert a tiny stimulus into a large response through resonance as a coherent system. Thus, even a trivial stimulus could affect a biological system.

Discovery of the Small Stimulus of Environmental Stressors as Potent Medicines in the Evolution of Mankind

The story of the discovery of environmental stressors as potent medicines is fascinating. Paracelsus was the first to declare that what makes a man ill also cures him in small doses. It was an anticipation of homeopathy (Web ref. 3). Paracelsus stated further, "No illness is that grave... that would not have its cure in a medicine" (Whitmont, 1993, p.1). The observations of Paracelsus were examples of the law of similars, *i.e.*, "like cures like," known since time immemorial (Fisher, 2010).

Samuel Hahnemann (1755-1843) was an orthodox medical practitioner. He shifted his medical practice to be solely based on the law of similars (Haehl, 2003). Drugs he used can be identified as environmental stressors, which he diluted to reduce toxicity (Upadhyay, 2020). His early treatments can be taken as "hormetic" treatments, as the drug was still present in measurable quantity in the doses prescribed (Upadhyay, 2020). He noted that such diluted drugs acted better (or were more "potent") when he administered them to patients in their homes, to which he traveled on a horse cart through bumpy streets. He got the idea to start diluting the source drug with violent strokes at each dilution level. To his astonishment, he found that the higher such dilution was, the more effective it was. He called this typical dilution process the "potentization" of the source drug as such dilution amplified its properties. A similar serial dilution but without strokes was therapeutically ineffective. A recent study based on patterns obtained from evaporating droplets of such dilutions agreed that the succussion of these dilutions brings changes in them, and this change matters. Patterns were examined "by means of computerized image analysis regarding grey level distribution, texture, and fractality" (Kokornaczyk *et al.*, 2020).

Hahnemann triturated a source-drug serially with lactose if it was not soluble in water or alcohol. A 12-time serial dilution/trituration in centesimal scale (1: 99) crosses Avogadro's limit. The processed drug so prepared is called "the medicine in 12C potency," bearing the name of its source drug. Beyond this limit, there is hardly any chance of finding the source-drug substance in a dose administered to a patient. Hahnemann used such dilutions up to 30C potency. Homeopathic practitioners often prescribe medicines in much higher potencies to obtain better results, usually up to 100,000C for many medicines (Vithoulkas, 1993, p. 165; Kent, 1986 reprint, p. 280).

Homeopathic medicines' source drugs are the substances through which life evolved and achieved its present form. They can be from any origin: minerals, animals, plants, magnetic fields, and electromagnetic radiation, including morbid secretions/parts from the diseased organism (Kayne, 2006, ch. 4). Emil von Behring was the first awardee of the Nobel Prize in Physiology or Medicine for "his work on serum therapy, especially its application against diphtheria, by which he has opened a new road in the domain of medical science...." (Web ref. 4). He appreciated Hahnemann and credited homeopathy for his work (Bellavite *et al.*, 2005; Coulter, 1994, pp. 96-98; Ullman, 2007, pp. 116-119).

A study compared the effectiveness and safety of specific sublingual immunotherapy to "non-specific" homeopathic therapy to treat intermittent and persistent allergic rhinitis. This study was published in a reputed journal of allergy/immunology and found that homeopathic interven-

tion did better (Filtchev and Dimov, 2010). Homeopathy is a highly individualistic therapy; the "specific" homeopathic intervention per an individual patient's symptoms would have been more helpful than such "non-specific" or general intervention of its medicine.

Hahnemann did clinical trials of a drug/medicine in a unique way. He administered the chosen drug in a non-toxic material dose as well as in various high potencies to healthy volunteers. He carefully recorded the symptoms that developed. This typical clinical trial of the drug was termed drug proving. Hahnemann also collected symptoms developed in those who suffered accidental poisoning of the drug substance. Thus, observations were made carefully and systematically. In this way, Hahnemann explored all possible therapeutic characteristics of the medicine to prescribe it successfully to treat patients suffering from similar symptoms (Hahnemann, 2013, ch. 4). Thus, he developed his theory on pure observations, not speculation (Whitmont, 1991, p. 32).

Many scientists have studied the physical (Bell, 2020b; Bellavite *et al.*, 2014a; Smith, 2015; Smith, 2008; Schulte and Endler, 2015; Yinnon, 2020; Yinnon, 2018; Konovalov and Ryzhkina, 2014; Elia *et al.*, 2014; Elia *et al.*, 2012; Upadhyay and Nayak, 2011) and biological (Bell, 2020a; Bellavite *et al.*, 2014b; Khuda-Bakhsh, 2014) properties of homeopathic dilutions and found them different than controls. The Nanoparticle - EZ Shell Model (Upadhyay, 2017; Upadhyay, 2020), developed to describe and explain the working mechanism of such dilutions, is likely to complement such studies. A recent comparative study finds this model best to understand such a dilution as homeopathic medicine and as an agent causing hormesis (Ullman, 2021). This model can be instrumental to understanding evolution as hydrophilic nanoparticles are ubiquitous, obviously with EZ water on their surface.

Nanoparticle-EZ Shell as Elaborately Evolved Environmental Stressor

Water-borne nanoparticles are ubiquitous. Their minimal size, ranging from 1 to 100 nanometers, makes them highly mobile and chemically reactive. Such nanoparticles are central in buffering environmental systems, serving the dual role of limiting potentially toxic metal concentrations while at the same time providing a supply of metals at levels that enable biochemical reactions to take place (Hartland *et al.*, 2013).

Turbulent serial dilutions of the environmental stressor happen spontaneously and contain nanoparticles. These nanoparticles often have some silica, a widespread mineral on Earth. Similarly, nanoparticles present in homeopathic medicine are rich in silica. Silica leaches from glass container walls and can be present in impurities present in water (Upadhyay and Nayak, 2011). Thus, a homeopathic medicine preparation simulates the serial turbulent dilution of the same environmental stressor in the environment happening spontaneously. The difference is only in adopting a scale for dilution, a centesimal (1:99), or another scale to standardize the prepared medicine (Upadhyay, 2020).

How can such a dilution store information? The EZ can remember its experience. But it erodes naturally with time by combining a hydronium ion (H_3O^+) with the EZ structural unit (OH^-), resulting in two water molecules (Pollack, 2013, pp. 95-97). However, a steady-state is reached when EZ growth balances natural EZ attrition by absorbing infrared energy from the environment (Pollack, 2013, pp. 95-97). Thus, any information stored with the EZ alone would fade away with time, perhaps within 200 hours; and so, the EZ alone cannot explain the prolonged shelf-life of homeopathic medicine.

The quantum phenomenon becomes effective for small particles exhibiting strange and counterintuitive effects in their operations. For example, a hydrophilic nanoparticle can act as an environmental sensor due to its dynamic structure. Further, water on its surface is irremovable at room temperature (Zhang *et al.*, 2003). This information led to the idea that EZ, along with hydrophilic nanoparticles as substrate, can explain the prolonged memory observed with homeopathic medicine if they could also address its nuances (Upadhyay, 2017).

Thus, the present author proposed "The Nanoparticle - Exclusion Zone (EZ) Shell Model" to explain the extraordinary properties of a turbulent serial dilution of an environmental stressor and its working mechanism. This model covers the following critical observations of pharmaceutical importance, which may also be helpful to understand evolution (Upadhyay, 2017):

- A simple dilution without succussions is devoid of therapeutic value.
- A higher potency of a remedy often is more effective, covers more symptoms, and is longer acting than a lower potency.

- Some therapeutically inert substances start acting as medicines at much higher potencies.
- Higher potencies of an insoluble source-drug can be raised in liquid, in addition to solid form, from its 3C (or afterward) triturated state.
- Initial potencies (up to 3C) of unstable source-drugs such as ammonium carbonate ($(NH_4)_2CO_3$) and "magnetized" water cannot be kept for long, but their higher potencies have prolonged shelf-lives. Silver nitrate ($AgNO_3$), up to 3C, must be protected from light.

This model has enough theoretical support and has been successful in its purpose (Upadhyay, 2017; Upadhyay, 2020; Ullman, 2021). Its robustness is evident. It easily explains two formidable challenges: First, homeopathic medicines, despite being in extreme dilution, are not as sensitive to impurities as they should be because the EZ shell would not allow almost anything in. Also, it is an emergent of the chaotic process. An emergent is relatively insensitive to perturbations or errors (De Wolf and Holvoet, 2005). Secondly, if stored correctly, it has an unlimited shelf-life. It could be so because, as Zhang *et al.* (2003) observed, water is highly polar and cannot be removed from the surface of the hydrophilic nanoparticle at room temperature. Further, among the polar liquids, water forms the thickest EZ layer at the hydrophilic surface (Chai and Pollack, 2010).

This model suggests that up to 3C potency, the source-drug information is extracted in condensed form by nanoparticles and EZ shells. This information extraction is possible due to nanoparticles' surface structure and surface energetics. Their surface is prone to adsorption and doping, and even surface imprinting is possible (Cumbo *et al.*, 2013). Further, their surface is vital (Mudunkotuwa and Grassian, 2011).

This model suits both particle-like and wave-like nature because the size of the nanoparticle-EZ shell is in the nanoscale. However, in quantum field theory, such differentiation fades away. The uncertainty relationship suggests as follows:

$\Delta N \, \Delta \Phi \geq h$

Where N is the number of quanta, *i.e.*, the atoms or molecules for the matter field, Φ is the field's phase (or rhythm of oscillation), and h is the Planck constant (Del Giudice *et al.*, 2010).

If N is well defined, Φ will become undefined. Then the model would become more particle-like or atomistic. If Φ is well defined, N will become undefined. Then this model would describe an open system; more a wave-like nature described better by a field.

Iteration constitutes the creation of information as it amplifies the differences (Green, 1991). In raising the potency, the EZ present on the "seed" nanoparticles spreads in the whole solution during succussions. This spreading may "spread" the information the EZ carries to the whole of the solution. Thus, iterations, *i.e.*, potentization, can be carried out to advantage until all information content is evolved enough to be fully "decipherable" to biological systems. It is the elaborative evolution of information (Upadhyay, 2017). Thus, nanoparticle-EZ shells in turbulent serial dilution of an environmental stressor/homeopathic medicine can be suggested as elaborately evolved environmental stressors. Stochastic resonance amplifies weak signals taking energy from the noisy background (Bell, 2020a; Sejdić and Lipsitz, 2013; Gammaitoni *et al.*, 1998). It is all within the purview of self-adaptive complexity /chaos theory. This theory is for relationships, iterations, and emerging patterns (Web ref. 5).

Molecules may generate, through electromagnetic emissions, an electromagnetically induced geometrical "template" to represent their group activity (Frazer and Frazer, 1987). In nature, the emerging patterns are often self-similar forming fractals. Fractals are just the consequence of the sequence of underlying nested quantum coherent dynamics (Vitiello, 2008). They belong to dissipative systems and squeezed coherent states and so are precise. They are ubiquitous, so quantum coherence is ubiquitous (Vitiello, 2012). Quantum coherence is involved with turbulent serial dilution, as happens in the environment/pharmacy. If the ambient (vacuum) electromagnetic field is blocked, such dilution does not produce biologically effective preparations. Many have observed it (Montagnier *et al.*, 2015; Konovalov and Ryzhkina, 2014; Ryzhkina *et al.*, 2011).

The present author infers that quantum coherence is involved in the evolution of information about a substance and its storage in nanoparticle-EZ shells as an information fractal. Therefore, different potencies of medicine may be taken as different information fractals of its source substance. How can an information fractal be a better player in evolution than matter?

Elaborately Evolved Stressor Versus Stressor: Superiority of Substance-Specific Information over Substance

Environmental stress can be characterized as a force that shapes adaptation and evolution in changing environments, and thus, is a property of both the stressor and the stressed (Bijlsma and Loeschcke, 2005). The role of stress or stressor in evolution has been a subject of study (Bijlsma and Loeschcke, 2005; Hoffmann and Hercus, 2000). However, the existence of elaborately evolved environmental stressors and their possibly more influential role in evolution has now been proposed (Upadhyay, 2020).

The simple-looking turbulent serial dilution or trituration of a substance can make a big difference in the properties of a dilution so prepared. Incredibly, this way, some inert substances like silica, sepia, and lycopodium evolve into potent medicines, *i.e.*, stressors. After around 30 iterations on a centesimal scale, they start exhibiting medicinal properties and become excellent medicines at very high potencies. Similarly, some dietary substances become excellent medicines, *i.e.*, stressors, especially at very high potencies. In this regard, common salt, *i.e.*, sodium chloride, as medicine has brought much ridicule to homeopathy. Still, at the same time, it has won the favor of many, too, who saw or experienced the effect themselves. This dichotomy occurs because the secondary action drawn from an elaborately evolved form of such a common dietary substance can really make a healthy person sick and can heal patients suffering similarly (Kayne, 2006; Kent, 1990 reprint; Hahnemann, 2013 edition, ch. 4).

Similarly, three noble gases, namely helium, neon, and argon, were recently potentized and proved for medicinal properties. Surprisingly in potentized form, they became unique medicines and are now used in clinical practice (Sherr, 2012; Sherr, 2013). As noble gases are chemically inert, homeopathic medicines are unlikely to act through direct chemical interactions, nor do they have such chemicals to interact.

Lithium and sodium's spectral "signatures" were found present in low-temperature thermoluminescence of ultra-high dilutions of lithium chloride and sodium chloride, respectively prepared with violent strokes at each dilution level (Rey, 2003). Some scientists even claimed that the dilution degree (potency) as well as the source-drug of homeopathic medicine, which is hardly present in it, can be identified through delayed luminescence study of the medicine. The signals detected were photons of coherent quantum character (Lenger *et al.*, 2014).

The electromagnetic nature of the biological dynamics and the central role of water in it is evident from fantastic work led by Nobel laureate Luc Montagnier and colleagues. They observed that serially diluted and vortex-agitated bacterial DNA sequences in water emitted low-frequency (500–3000 Hz) electromagnetic signals above a dilution threshold. Further dilution of this solution with agitation instead increased the intensity of the electromagnetic signals. It could happen essentially when the very-low-frequency ambient electromagnetic field of a few Hz was present. No signals were detected when this ambient field was blocked by shielding the sample by mu-metal, or the amount of water was below the critical threshold. Thus, the ambient electromagnetic field and water are essential components for this phenomenon (Montagnier *et al.*, 2015; Konovalov and Ryzhkina, 2014; Bischof and Del Giudice, 2013; Ryzhkina *et al.*, 2011).

Montagnier and colleagues observed further that these signals affected the pure water, kept in another vessel at much distance, including nanostructures present in the water. The effect was such that when the primary chemical components of DNA were added to this water, the original DNA sequences were retrieved. These signals, as explained theoretically, could induce a space-time distribution of the phase. This phase, in turn, could induce the electromagnetic potential in the pure water kept at a distance. This potential, in turn, could drive the formation of the original DNA sequences once the necessary biomolecules were supplied (Montagnier *et al.*, 2015; Bischof and Del Giudice, 2013; Montagnier *et al.*, 2011).

Similarly, Elia *et al.* (2012) reported that the pure water samples kept close to the extraordinarily diluted and agitated solutions followed them and thus altered over time. According to them, these alterations happened due to electromagnetic emission by these solutions.

In a prolonged and multicenter study, Endler *et al.* (2015) experimented with thyroxine (tetra-iodo-thyronine sodium pentahydrate) in the metamorphosis of highland amphibians. They diluted thyroxine with violent strokes at each dilution level up to $1:10^{30}$. Such an extreme dilution would not have any molecules of thyroxine left in it. Nevertheless, Endler *et al.* (2015) repeatedly observed that when they added it to the basin of water where the experimental animals were, as well as when they hung

it sealed in glass vials in this basin of water, it affected animals similarly in both cases. For example, the climbing activity of juvenile frogs was affected.

Thus, physical sciences become essential to explore the observed phenomena. Nature has four known fields (or forces): the strong, the weak, the electromagnetic, and the gravitational. While the strong and the weak fields are the short-range nuclear fields, the gravitational field becomes apparent only with enormously massive bodies. Thus, the only option left is the electromagnetic field. Further, as the organism is made of charged particles in motion, this field must be a part of the organism. Moreover, the quantum vacuum has been increasingly understood to be the central fundamental entity on which the physical description of reality is based (Zeiger and Bischof, 1998). Thus, quantum field theory best suits understanding the observed phenomena.

An EZ can hold information possibly through coding by removing oxygen atoms from its hexagonal lattice without impairing its structural integrity (Pollack, 2013, pp. 62-63). As such, a nanoparticle–EZ shell, much like an atom or molecule, may radiate characteristically, passing the information it contains. It would be an extremely particulate or atomistic view of reality in quantum field theory. "This means that when we focus on the atomic structure of matter it loses its coherence properties and, vice versa, when we examine the phase dynamics of the system its atomic structure becomes undefined" (Del Giudice *et al.*, 2010).

Otherwise, the nanoparticle-EZ shell as a quantum coherence domain is like Dicke's electromagnetic cavity. It cannot radiate energy/photons directly. However, the biomolecules or nonaqueous molecules excited by it on its periphery by supplying energy can emit biophotons. Biophotons can carry phase-based bio information (Bajpai, 2007; Van Wijk, 2001). Thus, the organism may receive this apparent radiated information directly at the higher level of its organizational hierarchy. Therefore, it would be more effective than its source substance, as observed with homeopathic medicines (Upadhyay, 2020). It is realized that medicine in a higher potency, *i.e.*, more iterated, often works from the higher level of the organizational hierarchy of the patient, so for better results, potency should be chosen accordingly (Kent, 1986 reprint).

Biophotons belong to squeezed quantum states, *i.e.*, least Heisenberg's uncertainty, and, thus, have precise information (Bajpai, 2007). Gurwitsch called them "embryonal or mitogenetic radiation" (Beloussov *et al.*, 1997). It is an ultraweak electromagnetic broad-band (200–800 nm) radiation emitted by practically all living organisms (Bischof and Del Giudice, 2013; Popp *et al.*, 1994; Bischof,1995). Pietak (2012) observed, "The proven existence of endogenous EM radiation would revolutionize the biological sciences by introducing a radically new mechanism underlying morphogenesis."

Further, the coherent/EZ water is also a source of superconducting protons present outside of its domain. These protons can cause rapid intercommunication within the body consuming a little energy (Ho, 2014b; Bischof and Del Giudice, 2013). Thus, the quantum coherent phase of water is "the means, medium and message of life" (Ho, 2014b).

The coherence domain must draw energy continuously from the environment for being dissipative. Water is an excellent absorber of infrared radiation, particularly at a 3,000 nm wavelength. The other possible source for continuous energy supply is the quantum vacuum (Montagnier *et al.*, 2015; Bischof and Del Giudice, 2013; Montagnier *et al.*, 2011; Upadhyay, 2002). As the Lamb-shift or the Casimir effect (Casimir, 1948) shows, the quantum vacuum can exchange energy and momentum with the matter. It also must play a role in preserving information in the coherence domain. In the absence of its field, turbulent serial dilution of a stressor becomes like a simple, *i.e.*, unagitated, dilution without any extraordinary properties (Ryzhkina *et al.*, 2011; Montagnier *et al.*, 2015; Konovalov and Ryzhkina, 2014).

Information plays a vital role in the success of living organisms (Glattfelder, 2019; Polani, 2009; Fels, 2009). Theories and experimental evidence on electromagnetic cellular interactions are continuously accumulating (Cifra *et al.*, 2015; Cifra *et al.*, 2011; Van Wijk, 2001). A growing body of evidence suggests that the molecular mechanism of life emits and absorbs photons (Web ref. 6). Fels's (2009) study strongly supports "a cellular communication system, which is different from a molecule-receptor-based system and hints that photon-triggering is a fine tuning principle in cell chemistry." Nevertheless, how can the weak intensity emission be detected by cells in a noisy electromagnetic background (Kučera and Cifra, 2013)?

A recent experimental study hints at the link between biophotons and the emergence of quantum coherence through diffusion entropy analysis (Benfatto *et al.*, 2021). Further, after observing short quasi-periodic bursts in

photon radiation from fish and frog eggs, a study claimed that the communication mechanism could be similar to exchanging binary encoded data in the computer nets via noisy channels without being affected. Moreover, the fish egg radiation data suggested that the information encoding is like the digit-to-time analog algorithm (Mayburov, 2012). The DNA, however, cannot be expected to be coded for the full complexity of life. Further, the genetic code on its own appears to be an output of coherent dynamics (Vitiello, 2014). Moreover, biological information can be in the configuration rooted in relationships. These relationships are not "invariants and depend on the context, the history and the specific perceiver" (Renati, 2020).

Therefore, the present author infers that coherent water's peculiar property makes substance-specific information important and more vital than the substance itself. Nanoparticle-EZ shells as agents seem to strengthen this phenomenon. They could lead to biological evolution utilizing environmental stressors in the buildup so that the organism could be compatible with the stressors. Nature could do so as it can handle information more conveniently than matter. While matter can act on contact, information can work subtly, from a distance, even when too feeble. Information can evolve and can be transferred with ease. It can be communicated directly to a higher level in an organism's organizational hierarchy, making it more effective. Thus, nature could prefer it over matter in biology and evolution. The toxic Earth could convert itself into mother Earth through morphogenesis that utilizes information the most.

Biological or Morphogenetic Field: Evanescent Electromagnetic Field with Feedback-based 4-Dimensional Bio-architectural Information

Morphogenesis is the coming-into-being of living organisms (Coen, 2012). The electromagnetic fields and radiation play a leading role in morphogenesis (Renati, 2020; Bischof and Del Giudice, 2013; Levin, 2012; Rouleau and Dotta, 2014; Bischof, 1994). Goodwin (1987, 2020 reprint) and Goodwin *et al.* (1987) have argued strongly in their favor since the 1980s that they cannot be overlooked in biological operations. Still, their role is often ignored for the more visible chemical signaling and, to some extent, tensile forces in modern developmental biology (Levin, 2003).

The morphogenetic field is perceived as information-bearing global patterns that guide growth and form. It explains morphogenesis, both experimentally and conceptually, while the genetic mechanisms have failed to do so (Thorp, 2021; Levin, 2012). "The presence of form is hidden in a maze of cellular and molecular theories which explain how this supra-physical organizing entity mediates its effects" (Thorp, 2021).

Physiologically patterned electromagnetic fields exposure changes rat morphology during the perinatal period (St-Pierre *et al.*, 2007; St-Pierre *et al.*, 2008). Further, by delivering precise bioelectrical signals, Levin and colleagues (Levin, 2012; Web ref. 7) could make planaria flatworms grow two fully functional heads or two tails instead of one. In subsequent rounds of regeneration, these flatworms remained as such without needing further manipulations. Levin (Web ref. 7) observed, "Surprisingly, this permanent change in anatomy is produced not by editing the worms' genes but by targeting a different aspect of biology that is attracting renewed attention after being overlooked for nearly a century: bioelectricity."

Evolutionary implications of this observation are apparent with identical DNA sequences in "the normal 1-headed worms and yet have radically different behavior and body-plan architecture" (Levin, 2012). It demonstrates that biophysical, epigenetic aspects may play an essential role in evolution (Levin, 2012).

A bioelectric potential exists between the inside and the outside of a cell. As soon as this potential collapses, the cell is dead. Further, the bioelectric potential is not just a by-product of living but a medium that cells exploit to communicate with each other and the environment, forming "networks that are much more than the sum of their parts." Thus, Levin has concluded that bioelectricity is "the literal spark of life" (Web ref. 7). Like a battery, the EZ water can provide an "influx of energy currents into the interior regions of the cell to drive its metabolic processes" (Thorp, 2021).

Morphogenetic fields carry positional information "to integrate cell activity into a system-level patterning program enabling cells and tissues to discern their location relative to each other within a complex 3-dimensional structure" (Levin, 2012). Further, it should have a "prepattern – a scaffold that serves as a template (to some level of detail) for the shape being assembled or repaired" (Levin, 2012).

An organism is an ensemble of quantum coherence domains and thus, is in a state of supra-coherence. This super coherence provides a holistic nature to the organism, mostly water in the EZ, *i.e.*, coherent phase. The non-diffusive dynamics offered by quantum coherence domains at their periphery are particularly important for a growing organism. Such domains attract a lot of molecules to their surface through the field already formed within them. This frequency-based attraction is not random and happens in a highly coordinated way and is thus free of biochemical mistakes. Apparently, besides three spatial dimensions, it brings in the time dimension to be honored in the buildup. Though the electromagnetic field is long-range, it falls off exponentially beyond the electromagnetic cavity, *i.e.*, the coherence domain. This evanescent electromagnetic field is responsible for all these activities and can be termed the morphogenetic field (Bischof and Del Giudice, 2013).

Thus, more than bioelectricity or even quantum mechanics (QM) would be required to help answer the question Levin (2011, 2012, Web ref. 7) has raised:

> Beyond protein and gene regulatory network profiling, how is patterning information stored and processed in dynamic physiological networks of biological systems so that they can behave adaptively, build large functional structures, and resist challenge?

QM ignores quantum fluctuations and the interaction between the matter field and the electromagnetic vacuum field (Ho, 2015). It does not provide the proper mathematical formalism to study the living matter. Further, it is not helpful to describe phase transitions (Vitiello, 2001; Vitiello, 2012). Quantum field theory, in which quantum electrodynamics is a part, however, can help. Thus, quantum field theory developed for water, the matrix of life, should be applied to understand patterning information, its storage, and processing in biological systems. However, this would address just the tip of the iceberg. As already described, underneath the incredible phenomenon of the environmental stressor's information-pattern evolution is hidden in its turbulent serial dilutions. It could play its subtle role in making life possible in a hostile environment. If it is ignored, the present author realizes, neither morphogenesis nor evolution can be understood correctly and as a whole.

Environmental Stressor's Subtle Role in Evolution as Promoter of Growth/Repair

Hahnemann died in 1843, much before Darwin's theory of evolution in 1859. Thus, we need to see the homeopathic phenomenon in the broader context of evolution/adaptation to understand it better (Upadhyay, 2020; Bell, 2020a; Bell *et al.*, 2015). During drug proving, the symptoms developed in healthy persons are their adaptive responses to the drug (environmental stressor). Similarly, symptoms a patient exhibits are his adaptive responses to a morbific stressor from which the patient is suffering. The person's holistic adaptive responses (general symptoms for which the person describing them uses the word "I") are more critical in selecting a remedy than the response experienced with any body part (local symptoms for which the person describing them uses the word, "My"). The former denotes a higher degree of adaptation than the latter (Upadhyay, 2020). Surprisingly, Hahnemann realized this empirically at the end of the 18th century during his medical practice. He made emergence a central part of homeopathy's philosophy in the sense that a patient as a whole is more important than the patient's symptoms/disease (Hahnemann, 2013, ch. 1).

Self-organization and natural selection are fundamental forces that have shaped the natural world (Glancy *et al.*, 2016). Self-organization is a physicochemical phenomenon of great importance. It creates order out of chaos and turbulence. It forms functional units at the subcellular, cellular, tissue, and organismic levels and is at the core of biological processes (Saha and Galic, 2018).

Self-organization is typically defined as the evolution of a system into an organized form without external pressures (Prokopenko, 2009). However, the biological system is permanently coupled with the external environment (Renati, 2020; Maturana and Mpodozis, 2000; Maturana and Varela, 1987). Thus, life would have been compelled to respond or react to environmental stressors. As all self-organized systems are thermodynamically open and immersed in local environments, they are "constrained in some way by external templates" (Halley and Winkler, 2008). Thus, self-organization is the manipulative ability of the system to stabilize its structure and/or function in response to external circumstance/fluctuation, and so, it is adaptive (Banzhaf, 2009). It can be guided or directed (Banzhaf, 2009; Prokopenko, 2009).

The concept of autopoiesis also favors the organism's continued "cognitive" interactions with its environment during its life and evolution. However, the accepted changes are determined by the internal structure of the organism itself. As such, under erratic environmental dynamics, evolution is a natural drift. It is determined primarily by the inner coherence and autonomy of the living organism to compensate for a given perturbation (Luisi, 2003; Maturana and Varela, 1987).

Brassard and Lutolf (2019) could manipulate stem cell self-organization to build better organoids. They realized that the self-organization was actually "directed" and, thus, could be exploited to produce organoids that resemble native tissues. It strengthens the idea that whole organs could be reproduced in vitro. It would "revolutionize tissue engineering and will surely transform regenerative medicine" (Brassard and Lutolf, 2019).

The organism is like a giant dynamic super-coherent liquid crystal (Ho *et al.*, 2006). It is made up of nested and interwoven quantum coherence domains (Bischof and Del Giudice, 2013; Vitiello, 2008). Emergence is ubiquitous and helps to adapt (Crutchfield, 1994). The present author suggests that the best defense against the stressors of this toxic Earth would have developed when life evolved following or adapting to them, as much as possible, for their properties, even making them an integral part of the organism itself. As such, natural selection may better be described as the most cooperative organism thrives (Voeikov, 2015; Axelrod and Hamilton, 1981). As an extension of the previous work (Upadhyay, 2020), the present author perceives the following developments could happen:

> Life seems to have originated in the simplest form in the quantum coherence state. This development could happen through the immutable physical tools of electromagnetism, quantum coherence, self-organization, and emergence with water as its matrix. Quantum coherence created stability in the organism, *i.e.,* homeostasis. A stressor tried to disturb the coherence, and thus, harm the organism. The organism, a self-organized system, overcompensated for harm by its growth in defense under guided/constrained self-organization. It is hormesis. However, this growth led to the organism's increasing complexity and vulnerability to stressors, *i.e.*, diseases. The nanoparticle-EZ shells as quantum coherence domains bore a stressor's 4-dimensional geometrical information templates with a characteristic frequency. The evolving organism could attract nanoparticle-EZ shells with similar frequency electromagnetic fields and acquire information through their evanescent electromagnetic field interactions. Gradually, over time and even generations, the evolving organism's domain frequencies could come closer to that of the nanoparticle-EZ shells, leading to a better phase-locking of their evanescent electromagnetic fields. Thus, the organism could get the information with full geometrical details related to this stressor for its further growth. Alternatively, the nanoparticle-EZ shells could attract similar frequency biomolecules and non-aqueous molecules and supply energy to excite them to emit biophotons. These biophotons could possess the stressor-specific information nanoparticle-EZ shells bearing to carry out morphogenesis. Thus, by guiding self-organization, the environmental stressor could carry out morphogenesis to lead to evolution, reducing the organism's vulnerability.

Adaptation of any form is encoded in the genome (Sthijns *et al.*, 2016). Nanostructures present in the homeopathic remedy can cause adaptation (Bell *et al.*, 2015). Adaptive changes in the organism are induced as "salient, low-level danger signals to the biological stress response network. Activation of stress response effectors, including heat shock proteins, inflammasomes, cytokines and neuroendocrine pathways, initiate beneficial compensatory reactions across the interconnected networks of the organism as a complex adaptive system" (Bell and Schwartz, 2013). Further, homeopathic medicine can modulate cell defense response network constituents involving "gene expression, cytokine release, cell signaling, and cell stress mediators. Once triggered, nonlinear endogenous amplification processes facilitate evolution of the therapeutic response over time" (Bell *et al.*, 2015).

Taking a non-reductionist approach, the present author suggests the working mechanism of a turbulent serial dilution of an environmental stressor/homeopathic medicine could be as follows:

> An organism falls sick when, due to some stress/a stressor, the coherency of quantum coherence domains gets vitiated in phase and frequency. In acute disease, the organism dies or recovers on its own, depending on whether the vitiation in oscillation of the constituents of the quantum coherence domains is beyond or within the damping limit to reach the original state. But, if the supra-coherence of the organism gets vitiated, the disease becomes chronic. It will not

get cured on its own and will take longer to get rid of and perhaps more than one remedy in succession.

The vitiated domains of the sick would attract nanoparticle-EZ shells of the matching frequency administered as the remedy. The near resonance between the two would transfer energy to the vitiated domains. It would increase the vibrating amplitudes of the constituents but within limits as frequencies are similar but not the same. Thus, an initial aggravation and returning of the old symptoms, especially in the chronic case, are possible in the recovery of the sick organism. The coupling between the evanescent electromagnetic fields of the vitiated domains of the organism and that of the nanoparticle-EZ shells can transfer stressor-specific information to the vitiated domains for their recovery. Biophoton emission from the nanoparticle-EZ shells may also do this job. Thus, the so-called law of similars could come into existence.

The observation of Johnson and Lam (2010) that life is made up of the same substances as the inorganic world, and its processes are also often the same as the natural world supports the above suggestions. Thus, evolution could develop the organism utilizing the hostile environment in the buildup through compromised self-organization. Therefore, evolution could soften the adversary and even convert it into a beneficiary as a promoter of growth and repair. It is as if an elixir could emerge from poison. It is much like Schrödinger's observation (2013 reprint, ch. 1) that order emerges from disorder. Still, can something differentiate between animate and inanimate substances?

The Vital Force: Science's Renewed Interest in an Abandoned Concept

Science has discarded the concept of vital force. However, evolutionary biologist Ernst Mayr (1904-2005) found this concept's logic faultless. He was especially impressed by the arguments of Hans Driesch (1867-1941) (Mayr, 2002; Mayr, 1988).

Since ancient times, people have known that nature possesses healing power (Logan and Selhub, 2012). The damaging primary pharmacological action of a stressor and the organism's beneficial reaction to it appears beautifully in the statement of German philosopher Friedrich Nietzsche: "That, which does not kill us, makes us stronger."

To explain the healing power of nature, Hahnemann used the theory of vitality or the vital force, which was prevalent during his time, as was the Hippocratic *vis medicatrix naturae* (Teixeira, 2020; Waisse and Bonamin, 2016). He defined health, disease, and cures as the normal, abnormal, and recovered functioning, respectively, of the vital force unique to life (Waisse and Bonamin, 2016). Further, "Vitalists represented a holistic tradition; they were not willing to accept purely mechanical interpretations of biological phenomena. The discussion between holistic and mechanistic scientists resulted in the development of modern self-organization theories, such as system, network, and chaos theory" (Teut, 2001).

Thus, the "unscientific" vital force theory, one of the significant reasons to discredit homeopathy, is now attracting a critical view considering current knowledge (Milgrom, 2020; Teixeira, 2020; Waisse and Bonamin, 2016; Teut, 2001). Kirschner *et al.* (2000) wondered how the organism exhibits robust physiology and embryology despite potentially non-deterministic statistical operations. They suggested that it is due to "vital forces." They emphasized that ultimately this robustness, *i.e.*, "vital forces," would have to be understood scientifically. They insisted "to move beyond the genomic analysis of protein and RNA components of the cell (which will soon become a thing of the past) and to turn to an investigation of the 'vitalistic' properties of molecular, cellular, and organismal function."

Quantum coherence may explain laser-like precision as observed in biological operations. In a live organism, quantum coherence domains represent the unity of matter and the electromagnetic fields, constituting cell functioning in a typical way as if the vital force exists. Thus, living matter differs from inert, non-living matter from its unique active properties (Bischof and Del Giudice, 2013). Therefore, the term machine is highly inappropriate for biota, and Descartes' philosophy that an organism is a machine is inadequate. However, the differences between the two are declining with advancements in science and technology as self-organization is common if the latter is also dissipative and organic compounds can be synthesized from inorganic ones. Bongard and Levin (2021) cautiously bridge the two as, "At stake is a most exciting future: where deep understanding of the origins and possible embodiments of autonomy help natural and synthetic systems reach their full potential."

Thus, the observations made in this paper strongly suggest looking for a new theory of biological evolution that could address it from its very cause.

Novel Theory of Biological Evolution: Chaos/Complexity and Quantum Coherence-based Proposal with the Logic Behind It

Equilibrium is a rare and precarious state in the world we are familiar with (Prigogine, 1984, p. 128). Nonlinear dynamic systems are driven to far-from-equilibrium states. Earth systems, *i.e.*, geosphere, atmosphere, hydrosphere, and biosphere, are such systems. They are open to dissipating energy continuously. Such systems are inherently evolutionary (Green, 1991).

Evolutionary mechanisms interact to integrate the different Earth systems into a unitary evolutionary system. Thus, evolution in one sphere affects the evolution of other spheres (Fichter *et al.*, 2010a). Evolution has three essential mechanisms: elaboration, self-organization, and fractionation. Self-organizing evolutionary processes seem to be more pervasive and more important than the other two mechanisms (Fichter *et al.*, 2010b; Ball, 2001).

Evolution is neither confined to biology nor can it be studied in isolation. Further, it is not a linear process either, as often referred to in evolutionary biology. Moreover, Darwinian (and even contemporary) evolutionary theory has been confined to elaborating evolution. The only difference has been the use of the units of biological evolution. Such units are like genes, individuals, and species not common to all elaborating evolutionary systems (Fichter *et al.*, 2010a). But it is self-organization that pervades biology (Fichter *et al.*, 2010b; Goodwin, 2020 reprint; Wedlich-Soldner and Betz, 2018; Saha and Galic, 2018; Glancy *et al.*, 2016; Karsenti 2008; Johnson and Lam, 2010; Camazine *et al.*, 2001; Kauffman, 1993). Self-organization is the "unmistakable and inimitable signature of living systems" (Keller, 2005).

Life and Earth evolved together hand-in-hand (Fichter *et al.*, 2010a). The Gaia hypothesis (Lovelock, 1979) suggests that organisms and their environment evolved as a single, self-regulating system. This hypothesis does not contradict Darwinism. Instead, it extends it, considering evolutionary biology and evolutionary geology as a single science (Lovelock, 2003). Thus, a living system and its environment make an indivisible whole (Renati, 2020; Vitiello, 2001; Maturana and Mpodozis, 2000; Maturana and Varela, 1987). Earth has been full of numerous substances with which life grew and attained its present form. Only a few such substances have been proved for their suitability as medicines, *i.e.*, stressors. So, a treasure of medicines is likely to be hidden. Whitmont (1991, p. xii) even claimed that "for every possibility of illness pattern, there is also a substance pattern 'out there' which minutely duplicates it."

Gilbert, Opitz, and Raff are prominent biologists who challenged the adequacy of genetics to explain evolution on its own. They also questioned the devaluation of morphology. They demanded the rehabilitation of the biological field. They suggested that a new synthesis should reunite evolutionary and developmental biology. In this synthesis, morphogenetic fields should mediate between genotype and phenotype. They should also be a major factor in ontogenetic and phylogenetic changes. Further, gene products should be seen first to interact to create morphogenetic fields and then cause their effects. These fields would then decide how the organism develops (Gilbert *et al.*, 1996; Opitz and Gilbert, 1997; Bischof and Del Giudice, 2013).

Shapiro (1997), a molecular geneticist, studied the phenomenon of "directed mutation." He concluded that evolution happens by natural genetic engineering and not by the natural selection of random mutations (Shapiro, 2014). Renati (2020), through electromagnetic field study, also realized that the idea of evolution and adaptation based on "selection among a manifold of random variants" is not realistic. Instead, a quantum coherence-based qualitative physical theory with minimum ad hoc assumptions is required.

Quantum coherence is a sublime state of being the whole (Ho, 2014a). Weiss (1939) suggested that within the overall morphogenetic field of an organism, subsidiary fields are producing a nested hierarchy of fields within fields. This suggestion gets support from quantum field theory (Bischof and Del Giudice, 2013; Vitiello, 2008). Thus, it is fair for the present author to suggest that an organism can be a macro-quantum coherence domain built up of interknitted micro-quantum coherence domains with "canals/drains" of non-coherent, *i.e.*, ordinary, water for material transportation.

Thus, besides self-organization and emergence, their consequence extraordinarily active elaborately evolved

environmental stressors provide a strong reason for developing a new evolutionary biological theory. The present author theorizes the following in the framework of chaos /complexity and quantum field theory:

> An environmental stressor, mainly an elaborately evolved one, is the more significant driver of evolution than the organism or its genes. Its presence or dominance at the place or time made it naturally selected. It could lead to developing those mechanisms/qualities of the organism during its evolutionary history that it can now disturb (as in a "proving") or restore (as in a "cure"). Thus, it contributed to the organism's evolution at the molecular level, creating complexity through morphogenesis by its four-dimensional emergence patterns. Therefore, one by one, environmental stressors led to the whole organism's evolution guiding its inherent self-organizing properties. The most cooperative evolving organisms could thrive. Environmental stressors gradually developed a critical state in the organism, followed by its rapid speciation. Their permutations over permutations led to biodiversity in the long run. The quantum vacuum field is the unifying medium for evolution.

"Organisms can greatly affect their environments, and the feedback coupling between organisms and their environments can shape the evolution of both" (Kirchner, 2002). Thus, the proposed theory may have parallels with the Gaia hypothesis. The Gaia hypothesis (Lovelock, 1979) takes Earth as a single organism where living and non-living parts form a complex interacting system (Web ref. 8). This hypothesis suggests that the organisms engineered Earth to be a harmonious whole for them to live on it (Kirchner, 2002). On the other hand, the proposed theory suggests that Earth is a unified whole because it engineered the organisms to live on it. Thus, the proposed theory differs from the Gaia hypothesis. However, both agree that Earth and its evolution played a crucial role in biological evolution. The Gaia hypothesis takes Earth systems as one giant living organism. Thus, it can be much broader in scope to study the influence of life on Earth (Lovelock, 1979), but this hypothesis is highly controversial (Web ref. 8).

The Proposed Theory versus Contemporary View of Biological Evolution

Along with Alfred Russel Wallace, Charles Darwin suggested that evolution took place gradually through natural selection, giving rise to adaptation. Thus, speciation occurred from common descent with modification (Darwin, 1859). However, in the early 20th century, taking the ideas of natural selection, genetic variation, and Mendelian inheritance, the so-called modern synthesis was carried out from "the eclipse of Darwinism" (Huxley, 1942).

The idea that evolution occurs gradually contradicts the fossil records, which show that new species appeared suddenly and then persisted in that form for a prolonged period. So Eldredge and Gould (1972) proposed the theory of punctuated equilibrium, which suggests that speciation occurs rapidly followed by a long stasis period. Gould and Lewontin (1979) even questioned adaptationism, *i.e.*, the very idea of natural selection. Thus, there has been a demand that evolutionary biology needs urgent reform with the only certainty that something needs to change (Welch, 2017; Pigliucci, 2007; Chorost, 2013; Pennisi, 2016).

Laland and colleagues (2014) wrote in *Nature* the following:

> Charles Darwin conceived of evolution by natural selection without knowing that genes exist. Now mainstream evolutionary theory focuses almost exclusively on genetic inheritance and processes that change gene frequencies.
>
> Yet new data pouring out of adjacent fields are starting to undermine this narrow stance. An alternative vision of evolution is beginning to crystallize, in which the processes by which organisms grow and develop are recognized as causes of evolution.

About the extended evolutionary synthesis (EES) (Pigliucci and Muller, 2010), Laland and colleagues (2014) wrote further:

> In essence, this synthesis maintains that important drivers of evolution, ones that cannot be reduced to genes, must be woven into the very fabric of evolutionary theory.

However, many biologists like Gregory A. Wray and Hopi

E. Hoekstra do not accept or see differently the arguments made in favor of extended evolutionary synthesis (EES). They see EES as "new words, old concepts" and insist on the prevalent concept that "genes are central" (Laland *et al.*, 2014). Consequently, they are satisfied with the improved version of modern synthesis called standard evolutionary theory (SET). They see scope in it for further expansion if required. Thus, dissatisfaction and confusion are prevailing in contemporary evolutionary biology. It requires a coherent theory based on the physical framework, which can describe and predict observations.

The chaos/complex system theories provide a natural and logically inevitable explanation of evolution. It also successfully explains how elaborating evolution can lead an ecosystem to collapse or go extinct through self-organized criticality without taking refuge in any ad hoc explanation. Mathematically, this happens through a power-law distribution (Fichter *et al.*, 2010a; Fichter, 2010b). Thus, after many iterations, *i.e.*, generations, the slightest differences may cause one species to flourish and another one to go extinct. It is like Lorenz's butterfly effect, in which a minor change in a nonlinear system can result later in major differences (Fichter *et al.*, 2010b). Thus, the chaos/complex system theories explain both micro- and macro-evolution. They also explain that phylogeny is fractal (Green, 1991).

"The early Earth was very different from the planet we live on today" (Fichter *et al.*, 2010a). It was too hostile and toxic. Life evolved with repeated turbulent dilutions of environmental stressors around it. Such dilutions, as already explained, were elaborately evolved for stressors' properties. This elaboration could happen through the stressor's physical pattern emergence by deterministic chaos. Such emergence as tapestries is found in physicochemical and biological worlds alike to blur the imaginary boundary between them (Ball, 2001).

The present author suggests that the most important driver of evolution is neither the organism as suggested by Laland *et al.* (2015) nor its genes as suggested by Dawkins (1976), but the environmental stressor, more so in its elaborately evolved version devoid of toxicity. It must be in the roots of biological evolution and thus, woven into the very fabric of evolutionary theory. The very existence of homeopathy would not have been possible if environmental stressors had not been instrumental in developing the organism and its genes. The organism, utilizing self-organization and elaboration through generations, *i.e.*, iterations, could develop, making the stressor's physical pattern part of it to be compatible with it. If afflicted, the similarly affecting stressor, as a medicine, could heal it. Hence, Earth systems seem to play a much more significant role in building up life than usually thought in evolutionary biology.

Even in its extended evolutionary synthesis (EES), the contemporary theory studies biological evolution only of the elaborating kind. Thus, contemporary theory learns evolution mainly from its macroscopic "exterior." On the other hand, the proposed theory extends the existing physical theory of deterministic chaos, considering empirical evidence of the biological effects of the secondary action of the environmental stressors from the practice of homeopathy. The essential physical tools like electromagnetism with quantum coherence and self-organization with emergence may lead to the buildup of life in the lap of Earth and its environment, *i.e.*, in direct interaction with them. It could happen with the help of the underlying unifying field of the quantum vacuum. Thus, the proposed theory may cover biological evolution from its deep "interior." Hence, the contemporary and proposed theories may complement each other if the environmental stressor's secondary action is evolutionary, as shown.

Discussion: More on Environmental Stressor's Secondary Action and its Evolutionary Potential

All living organisms obey the celebrated Weber-Fechner Law of physiology. It states that response is proportional not to the stimulus but the logarithm of the stimulus. Thus, the response grows slowly with the stimulus, protecting the organism from too much of it. However, what could happen when its intensity falls below the threshold value was ignored as non-existent and the graph for this reason as nonsense (Tosi and Del Giudice, 2013; Brizhik *et al.*, 2011). The graph for this law is plotted between Response at Y-axis and the Stimulus logarithm at X-axis. Below the threshold value of stimulus, response proliferates but in the negative direction of the Y-axis as the stimulus decreases. It shows the response has turned to the inside to restructure and reorganize the organism more as the stimulus decreases. It forms the rational basis for the principle of minimum stimulus (Tosi and Del Giudice, 2013; Brizhik *et al.*, 2011). While the Arndt-Schulz Law is, in essence, a pure biochemical model, the Weber-Fechner Law goes deep into the quantum field theory. It may explain why homeopaths are happy with their "illogical"

extreme dilutions of environmental stressors as potent medicines.

Homeopathic medicine may work epigenetically as ancestral health conditions are also crucial in selecting the remedy. "In various instances, homeopathic medicines have shown their potential as chemotherapeutic remedies and their mechanism of action involves the reversal of the epigenetic signature unique to cancer cells" (Kanherkar *et al.*, 2017). *Nature India* also reported that homeopathic medicines modify gene expression in cancer cells (Web ref. 9).

A study at Harvard University on the National Health Interview Survey Report found a 15% increase in homeopathic medicine in the United States between 2007 and 2012. Those who consulted a homeopathic practitioner were far more satisfied with homeopathy and said something like homeopathy was "very important in maintaining health and well-being" and that it was "a great deal" for their health condition (Dossett *et al.*, 2016). According to a report published in *The Lancet*, homeopathy is booming in the world's largest democracy, India (Prashad, 2007). Like India and Brazil, Switzerland recently included alternative medicine, including homeopathy, within its government-paid medical services (Web ref. 10). Amazingly, it is happening though only a few substances of nature have been tested for their potential as medicine. Further, research and development work in homeopathy is negligible compared to modern, *i.e.*, institutional, medicine.

The acceptance of the evolutionary theory proposed here may suffer from the skepticism that homeopathy is still facing. But this skepticism is mainly due to the still prevailing reductionist approach to studying an emergent phenomenon as homeopathy and its medicines are. However, despite all criticism, homeopathy is still widely practiced in spite of the tremendous development of modern, *i.e.*, institutional, medicine. Homeopathy has a two-century-long, rich history (Hoover, 2020). Many famous people have been its adherents (Ullman, 2007). Seeing its popularity and success in virtually every country globally for the past 200 years, the WHO has integrated it into health systems as traditional medicine (Poitevin, 1999).

Further, the specific mechanisms of action relevant to the therapeutic effects of most drugs used in modern medicine are also not known or clear (Web ref. 11). Some have been in use for as long as a century, yet there is no skepticism toward them. There can be two primary reasons behind this. First, these drugs perform satisfactorily in double-blind clinical trials designed to test the efficacy of drugs of generalized action, as they are. Secondly, a drug in the material form suits conventional human wisdom due to its visibility, which homeopathic medicine is devoid of as it hardly contains the source drug.

The remedy selection in homeopathy is not easy. The primary reason is that it is a holistic therapy, so the remedy is selected for the patient, not directly for the disease. Thus, the patient is required to be understood mentally, physically, and socially. But it requires sufficient exposure of the patient to the practitioner. Further, the symptoms collected from a patient do not guide equally to reach the remedy. A symptom's importance varies as to how much it represents the patient as a whole, *i.e.*, the degree of patient's adaptation to the morbific stress causing the symptoms. Thus, the remedy selection requires much skill and expertise on the practitioner's part (Upadhyay, 2020; Upadhyay, 2005).

Therefore, the biological potential of the secondary action of the environmental stressor as observed in homeopathic therapeutics should be far more than what the success of homeopathy convinces us about it. Thus, it is compelling enough to lead to biological evolution, especially when biological evolution is an excessively gentle/slow process. Further, even a trivial stimulus can significantly affect a biological system/evolution (see previous sections). The Weber-Fechner Law of physiology justifies this observation through quantum field theory, and thus, is valuable to understand evolution through the secondary action of environmental stressors.

Conclusion

Life forms are open and dissipative and so inherently evolutionary. Thus, evolutionary biology requires a coherent theory based on the physical framework describing and predicting observations. Otherwise, it may be treated simply as a history of "just one damned thing after another" (Fodor and Piattelli-Palmarini, 2011) or even storytelling (Gould and Lewontin, 1979). Its contemporary theory only covers an elaborating kind of evolution while self-organization pervades biology. Thus, evolutionary biology cannot remain confined to observations made externally.

Further, the world is non-deterministic and statistical, but surprisingly biological operations happen with utter ac-

curacy (Kirschner et al., 2000). Further, nature has been even elusive when under probe (Josephson, 1992). Thus, empirical knowledge and observations are important (Ball, 2008). They are direct experiences. They are relevant evidence to develop an otherwise impossible theory (Josephson, 1992).

Moreover, the peculiar nature of water has been ignored in the study of biological evolution though water is the matrix of life. Instead of one, liquid water flickers between two phases. The dominating phase is the ordinary (bulk) water, while the remaining is coherent, *i.e.*, exclusion zone (EZ), water. The coherent water forms quantum coherence domains. They trap electromagnetic fields from the environment while ordinary phase water is indifferent to them. Almost all biological water is coherent and makes the living organism highly sensitive to the environment.

The Weber-Fechner Law of physiology justifies this hypersensitivity. Quantum field theory reveals the whole meaning of this law. Below the threshold value of the stimulus, the organism's response to stimulus not only exists but increases for its decreasing value in the negative direction of the Response axis. It happens because of the inward action of the minimal stimulus on the organism leading to its increasing organization or coherence (Tosi and Del Giudice, 2013; Brizhik *et al.*, 2011). Thus, this law helps understand evolution through the secondary action of environmental stressors.

The proposed theory identifies electromagnetism, self-organization, emergence, and coherence as essential evolutionary tools. It takes electromagnetic potential and the oscillation phase as the biological agents that store and communicate information with the help of the unifying quantum vacuum. "Information" is increasingly known to represent the ultimate nature of reality, and the trusted "materialistic and reductionistic scientific worldview" is now outdated (Glattfelder, 2019, p. 473). The interplay between the physical and the abstract realms is possible. Knowledge can be created through mapping aspects of the natural world into formal representations and back again through encoding/decoding (Glattfelder, 2019, pp. 78-79; Casti, 1989). As such, the nanoparticle-EZ shell can be of particular interest. It constitutes a unique quantum coherence domain with nanoparticle at the center. It is present in the environment, especially in water. During spontaneous turbulent serial dilution of an environmental stressor, it can evolve and store the four-dimensional geometrical information patterns of the stressor in the abstract realm. Quantum coherence is involved in this simply appearing process as for its success, the presence of the ambient (vacuum) electromagnetic field is necessary. Thus, the nanoparticle-EZ shell can act as an elaborately evolved environmental stressor capable of carrying out morphogenesis, and therefore, a key player in evolution. Any stressor or even some benign substances can ride on it to express their full biological potential otherwise hidden.

The theory suggests that the hostile Earth could become harmonious with the organisms because it engineered them to live with it. Its stressors could manipulate the inherent self-organization process for biological evolution through their four-dimensional geometrical information patterns. Environmental stressors, what they can disturb or restore in an organism, developed the same during its evolutionary history. Gradually, the organism reached a critical state over generations, followed by its rapid speciation; thus, the random permutations of stressors led to biodiversity. Therefore, the main driver of biological evolution is environmental stressors, not the organism or genes. The organism or its genes are in themselves the product of biological evolution and work through fundamental evolutionary tools.

Thus, this theory can bring evolutionary biology and evolutionary geology closer; similarly, it can do this with evolutionary and developmental biology and with evolved and designed systems. This theory can find a ready application in tissue engineering as stem cells are self-organizing. Therefore, regenerative medicine is one to test the validity of this theory. Further, this theory strongly suggests organizing our therapeutic system according to our evolutionary history. A drug treasure among the substances with which life grew largely lies hidden unexplored. Thus cheaper, safer, eco-friendly easy-to-make emergence-based medicines are possible (Upadhyay, 2020). One may even dream of tailor-made medicines prepared in pharmacies of the future instead of looking for them in the environment or the history of evolution (Upadhyay, 2005). Thus, a minimal stimulus-based new science of medicine may arise through quantum physics and be called quantum medicine.

Otherwise, the present scenario is grim. The WHO has already warned, "The burden of chronic diseases is rapidly increasing worldwide" (Web ref. 12). What is worse, antibiotic resistance has become a significant threat (Web ref. 13). There is also a global rise in infectious disease outbreaks (Smith *et al.*, 2014). At present, the Coronavirus

pandemic has crippled humanity.

It is an open fact that evolutionary biologists are dissatisfied with their theories, with the certainty that something needs to change (Welch, 2017). The proposed theory may bring a radical change in their thinking. This theory attempts to cover evolution from its very cause. Thus, it complements the contemporary theory of biological evolution based on its surface study. Therefore, it may broaden the horizons of evolutionary biologists, offering them the necessary insights. It may help mitigate their prevailing confusion and differences.

Crutchfield (1994) agreed with Goodwin and Sanders (1992) that, "There is a crying need for a theory of biological structure and a qualitative dynamical theory of its emergence." A theory for biological evolution with a holistic view of nature, as developed here, may help. This theory allows physics and complex systems science to work upon it and grow. Nature may appear obscure or bizarre, but is simple (Pollack, 2013). Let the scientific culture not discourage new ideas without testing them unbiasedly. (Benderly, 2016; Pollack, 2013, chs. 2,18; Barber, 1961).

Acknowledgments

The author expresses his deep gratitude to the assigned unknown Associate Editor for valuable critiques of this research work. The author would also like to thank the three anonymous reviewers for their helpful comments and advice.

Conflict of Interest

None.

Funds Received

None.

References

Anagnostatos GS (1994). Small water clusters clathrates in the preparation process of homoeopathy. In: Endler PC, Schulte J (eds). Ultra High Dilution. Dordrecht: Kluwer Acad. Publ., p. 121-128. https://doi.org/10.1007/978-94-015-8342-8_12

Anagnostatos GS, Vithoulkas G, Garzonis P, Tavouxoglou C (1991). A working hypothesis for homeopathic microdiluted remedies. Berlin J Res Hom 1: 141-147. https://doi.org/10.1016/S0007-0785(05)80310-2

Axelrod R, Hamilton WD (1981) The evolution of cooperation. Science 211: 1390-96. https://doi.org/10.1126/science.7466396

Bagatolli LA, Mangiarotti A, Stock RP (2021). Cellular metabolism and colloids: Realistically linking physiology and biological physical chemistry. Prog Biophys Mol Biol 162: 79-88. https://doi.org/10.1016/j.pbiomolbio.2020.06.002

Bajpai R.P. (2007) Quantum Squeezed State Description of Spectral Decompositions of a Biophoton Signal and the Possibility of Remote Intervention. In: Beloussov LV, Voeikov VL, Martynyuk VS (eds). Biophotonics and Coherent Systems in Biology. Boston, MA: Springer, pp. 33-46. https://doi.org/10.1007/978-0-387-28417-0_3

Ball P (2001). The Self-Made Tapestry: Pattern Formation in Nature. New York: Oxford University Press.

Ball P (2008). Water- an enduring mystery. Nature 452: 291-292. https://doi.org/10.1038/452291a

Banzhaf W (2009). Self-organizing Systems. In: Meyers RA (ed). Encyclopedia of Complexity and Systems Science. New York: Springer. https://doi.org/10.1007/978-0-387-30440-3_475

Barber B (1961). Resistance by scientists to scientific discovery. Science 134: 596-602. https://doi.org/10.1126/science.134.3479.596

Bell IR (2020a). The Complexity of the Homeopathic Healing Response Part 1: The Role of the Body as a Complex Adaptive System in Simillimum-Initiated Recovery from Disease. Homeopathy 109: 42-50. https://doi.org/10.1055/s-0039-1694998

Bell IR (2020b). The Complexity of the Homeopathic Healing Response Part 2: The Role of the Homeopathic Simillimum as a Complex System in Initiating Recovery from Disease. Homeopathy 109: 51-64. https://doi.org/10.1055/s-0039-1694999

Bell IR, Schwartz GE (2013). Adaptive network nanomedicine: an integrated model for homeopathic medicine. Front Biosci (Schol Ed) 5: 685-708. https://doi.org/10.2741/S400

Bell IR, Schwartz GE, Frye J, Sarter B, Standish LJ (2015). Extending the Adaptive Network Nanomedicine Model for Homeopathic Medicines: Nanostructures as Salient Cell Danger Signals for Adaptation. Nanosci Technol 2: 1-22. https://doi.org/10.15226/2374-8141/2/1/00124

Bellavite P, Conforti A, Piasere V, Ortolani R (2005). Immunology and Homeopathy. 1. Historical Background. eCAM 2: 441-452. https://doi.org/10.1093/ecam/neh141

Bellavite P, Marzotto M, Olioso D, Moratti E, Conforti A (2014a). High-dilution effects revisited. 1. Physicochemical aspects. Homeopathy 103: 4-21. https://doi.org/10.1016/j.homp.2013.08.003

Bellavite P, Marzotto M, Olioso D, Moratti E, Conforti A (2014b). High-dilution effects revisited. 2. Pharmacodynamic mechanisms. Homeopathy 103: 22-43. https://doi.org/10.1016/j.homp.2013.08.002

Bellavite P, Ortolani R, Pontarollo F, Piasere V, Benato G, Conforti A (2006). Immunology and Homeopathy. 4. Clinical Studies - Part 2. Evidence based complementary and alternative medicine: eCAM 3: 397-409. https://doi.org/10.1093/ecam/nel046

Bellavite P, Signorini A (2002). The Emerging Science of Homeopathy. Berkeley, California: North Atlantic Books.

Beloussov LV, Opitz JM, Gilbert SF (1997). Life of Alexander G. Gurwitsch and his relevant contribution to the theory of morphogenetic fields. Int J Dev Biol 41: 771-779.

Benderly BL (2016). How scientific culture discourages new ideas. Science. https://doi.org/10.1126/science.caredit.a1600102

Benfatto, M.; Pace, E.; Curceanu, C.; Scordo, A.; Clozza, A.; Davoli, I.; Lucci, M.; Francini, R.; De Matteis, F.; Grandi, M.; Tuladhar, R.; Grigolini, P (2021). Biophotons and Emergence of Quantum Coherence-A Diffusion Entropy Analysis. Entropy 23: 554. https://doi.org/10.3390/e23050554

Bigagli E, Luceri C, Dei A, Bernardini S, Dolara P (2016). Effects of extreme dilutions of Apis mellifica preparations on gene expression profiles of human cells. Dose Response 14:1-7. https://doi.org/10.1177/1559325815626685

Bijlsma R, Loeschcke V (2005). Environmental stress, adaptation and evolution: an overview. J Evol Biol 18: 744-9. https://doi.org/10.1111/j.1420-9101.2005.00962.x

Bischof M (1994) The history of bioelectromagnetism. In: Ho M-W, Popp FA, Warnke U (eds). Bioelectrodynamics and Biocommunication. Singapore: World Scientific. https://doi.org/10.1142/2267

Bischof M (1995). Biophotonen. Frankfurt: Zweitausendeins.

Bischof M, Del Giudice E (2013). Communication and the emergence of collective behavior in living organisms: a quantum approach. Mol Biol Int 2013: 987549. https://doi.org/10.1155/2013/987549

Bongard J, Levin M (2021) Living Things Are Not (20th Century) Machines: Updating Mechanism Metaphors in Light of the Modern Science of Machine Behavior. Front Ecol Evol 9: 650726. https://doi.org/10.3389/fevo.2021.650726

Brassard JA, Lutolf MP (2019). Engineering Stem Cell Self-organization to Build Better Organoids. Cell Stem Cell 24: 860-876. https://doi.org/10.1016/j.stem.2019.05.005

Brizhik L (2011). ON THE ROLE AND IMPACT OF ELECTROMAGNETIC FIELDS IN ECOSYSTEMS. Int J Design & Nature and Ecodynamics 6: 272-281. https://doi.org/10.2495/DNE-V6-N4-272-281

Brizhik L, Del Giudice E, Jørgensen SE, Marchettini N, Tiezzi E (2009a). The role of electromagnetic potentials in the evolutionary dynamics of ecosystems. Ecological Modelling 220: 1865-1869. https://doi.org/10.1016/j.ecolmodel.2009.04.017

Brizhik LS, Del Giudice E, Maric-Oehler W, Popp FA, Schlebusch KP (2009b). On the dynamics of self-organization in living organisms. Electromagn Biol Med 28: 28-40. https://doi.org/10.1080/15368370802708272

Brizhik LS, Del Giudice E, Tedeschi A, Voeikov VL (2011). The role of water in the information exchange between the components of an ecosystem. Ecol Model 222: 2869-2877. https://doi.org/10.1016/j.ecolmodel.2011.05.017

Bunkin NF, Ignatiev PS, Kozlov VA, Shkirin AV, Zakharov SD, Zinchenko AA (2013). Study of the Phase States of Water Close to Nafion Interface. WATER 4: 129-154.

Buzzacchi M, Del Giudice E, Preparata G (2002). COHERENCE OF THE GLASSY STATE. Int J Mod Phys B 16: 3771-3786. https://doi.org/10.1142/S0217979202012116

Calabrese EJ (2005). Toxicological awakenings: the rebirth of hormesis as a central pillar of toxicology. Toxicol App Pharmacol 204:1-8. https://doi.org/10.1016/j.taap.2004.11.015

Calabrese EJ, Baldwin LA (2000). Chemical hormesis: its historical foundations as a biological hypothesis. Hum Exp Toxicol 19: 2-31. https://doi.org/10.1191/096032700678815585

Calabrese EJ, Iavicoli I, Calabrese V (2013). Hormesis: Its impact on medicine and health. Hum Exp Toxicol 32:120-152. https://doi.org/10.1177/0960327112455069

Camazine S, Deneubourg J, Franks NR, Sneyd J, Theraulaz G, Bonabeau E (2001). Self-organization in Biological Systems. Princeton University Press.

Casimir HBG (1948). On the attraction between two perfectly conducting plates. Proceedings of the Koninklijke Nederlandse Akademie Van Wetenschappen B 51: 793-796.

Casti, J (1989). Alternate Realities: Mathematical Models of Nature and Man. New York: Wiley Interscience.

Chai B, Pollack GH (2010). Solute-Free Interfacial Zones in Polar Liquids. J Phys Chem B 114:5371-5375. https://doi.org/10.1021/jp100200y

Chorost M (2013). Where Thomas Nagel went wrong. Chronicle of Higher Education, May 13, 2013.

Cifra M, Brouder C, Nerudová M, Kučera O (2015). Biophotons, coherence and photocount statistics: A critical review. Jour Luminescence 164: 38-51. https://doi.org/10.1016/j.jlumin.2015.03.020

Cifra M, Fields JZ, Farhadi A (2011). Electromagnetic cellular interactions. Prog Biophys Mol Biol 105: 223-46. https://doi.org/10.1016/j.pbiomolbio.2010.07.003

Coen E (2012). Cells to Civilizations: The Principles of Change That Shape Life. Princeton: Princeton University Press. https://doi.org/10.1515/9781400841653

Coey JMD, Cass S (2000). Magnetic water treatment. J Magnetism and Magnetic Materials 209: 71-74. https://doi.org/10.1016/S0304-8853(99)00648-4

Colic M, Morse D (1999). The elusive mechanism of the magnetic "memory" of water. Colloids Surf A 154: 167-174. https://doi.org/10.1016/S0927-7757(98)00894-2

Collini E, Wong CY, Wilk KE, Curmi PM, Brumer P, Scholes GD (2010). Coherently wired light-harvesting in photosynthetic marine algae at ambient temperature. Nature 463: 644-647. https://doi.org/10.1038/nature08811

Cosic I (1994). Macromolecular bioactivity: is it resonant interaction between macromolecules?-Theory and applications. IEEE Trans Biomed Eng 41: 1101-1114. https://doi.org/10.1109/10.335859

Cosic I (1997). The Resonant Recognition Model of Macromolecular Bioactivity: Theory and Applications. Basel, Switzerland: Birkh¨auser. https://doi.org/10.1007/978-3-0348-7475-5

Coulter HL (1994). Divided Legacy: A History of the Schism in Medical Thought, Volume 4. Berkeley, California: North Atlantic Books, pp. 96-98.

Cowan ML, Bruner BD, Huse N, Dwyer JR, Chugh B, Nibbering ETJ, Elsaesser T, Miller RJD (2005). Ultrafast memory loss and energy redistribution in the hydrogen bond network of liquid H2O. Nature 434: 199-202. https://doi.org/10.1038/nature03383

Crubellier A, Liberman S, Pavolini D, Pillet P (1985). Superradiance and subradiance. I. Interatomic interference and symmetry properties in three-level systems. J Phys B 18: 3811-3833. https://doi.org/10.1088/0022-3700/18/18/022

Crutchfield, JP (1994). The calculi of emergence: Computation, dynamics, and induction. Phys D 75, 11-54. https://doi.org/10.1016/0167-2789(94)90273-9

Cumbo A, Lorber B, Corvini PF, Meier W, Shahgaldian P (2013). A synthetic nanomaterial for virus recognition produced by surface imprinting. Nat Commun 4:1503. https://doi.org/10.1038/ncomms2529

Darwin C (1859). The origin of species. London: John Murray Press.

Das S, Saha SK, De A, Das D, Khuda-Bukhsh AR (2012). Potential of the homeopathic remedy, Arnica Montana 30C, to reduce DNA damage in Escherichia coli exposed to ultraviolet irradiation through upregulation of nucleotide excision repair genes. Zhong Xi Yi Jie He Xue Bao 10: 337-346. https://doi.org/10.3736/jcim20120314

Dawkins R (1976). The Selfish Gene. Oxford university press.

Dei A, Bernardini S (2015). Hormetic effects of extremely diluted solutions on gene expression. Homeopathy 104:116-22. https://doi.org/10.1016/j.homp.2015.02.008

Del Giudice E, Elia V, Tedeschi A (2009). The Role of Water in the Living Organisms. Neural Network World 19: 355-360.

Del Giudice E, Preparata G, Vitiello G (1988). Water as a free electric dipole laser. Phys Rev Lett 61: 1085-1088. https://doi.org/10.1103/PhysRevLett.61.1085

Del Giudice E, Spinetti PR, Tedeschi A (2010). Water dynamics at the root of metamorphosis in living organisms. Water 2: 566-586. https://doi.org/10.3390/w2030566

De Ninno A, Congiu Castellano A, Del Giudice E (2013). The supramolecular structure of liquid water and quantum coherent processes in biology. J Phys: Confer Ser 442: 012031. https://doi.org/10.1088/1742-6596/442/1/012031

Denton MJ, Dearden PK, Sowerby SJ (2003). Physical law not natural selection as the major determinant of biological complexity in the subcellular realm: New support for the pre-Darwinian conception of evolution by natural law. Biosystems 71: 297-303. https://doi.org/10.1016/S0303-2647(03)00100-X

De Wolf T, Holvoet T (2005). Emergence Versus Self-Organisation: Different Concepts but Promising When Combined. In: Brueckner SA, Di Marzo Serugendo G, Karageorgos A, Nagpal R (eds). Engineering Self-Organising Systems. ESOA 2004. Lecture Notes in Computer Science 3464: 1-15. Berlin, Heidelberg: Springer. https://doi.org/10.1007/11494676_1

Dicke RH (1954). Coherence in spontaneous radiation processes. Physical Review 93: 99-110. https://doi.org/10.1103/PhysRev.93.99

Dicke RH (1964). The coherence brightened laser. In: Grivet P, Bloembergen N (eds). Quantum Electronics, Vol. 1. Proceedings of the 3rd International Conference on Quantum Electronics, Paris 1963. Paris: Dunod Éditeur and New York: Columbia University Press, pp. 35-54.

Dossett ML, Davis RB, Kaptchuk TJ, Yeh GY (2016). Homeopathy Use by US adults: Results of a National Survey. Am J Public Health 106: 743-745. https://doi.org/10.2105/AJPH.2015.303025

Editorial, The Lancet (2005). The end of homeopathy. Lancet 366: 690. https://doi.org/10.1016/S0140-6736(05)67149-8

Eldredge N, Gould SJ (1972). Punctuated equilibria: an alternative to phyletic gradualism. In: Schopf TJM (ed). Models in Paleobiology. San Francisco: Freeman Cooper, pp. 82-115. https://doi.org/10.5531/sd.paleo.7

Elia V, Ausanio G, Gentile F, Germano R, Napoli E, Niccoli M (2014). Experimental evidence of stable water nanostructures in extremely dilute solutions, at standard pressure and temperature. Homeopathy 103: 44-50. https://doi.org/10.1016/j.homp.2013.08.004

Elia V, Marrari LA, Napoli E (2012). Aqueous nanostructures in water induced by electromagnetic fields emitted by EDS: A conductometric study of fullerene and carbon nanotube EDS. J Therm Anal Calorim 107: 843-851. https://doi.org/10.1007/s10973-011-1484-y

Endler PC, Pongratz WC, Harrer B, Lingg G, Lothaller H (2015). Amphibians and ultra high diluted thyroxine-further experiments and reanalysis of data. Homeopathy 104: 250-256. https://doi.org/10.1016/j.homp.2015.10.001

Fels D (2009) Cellular Communication through Light. PLoS ONE 4(4): e5086. https://doi.org/10.1371/journal.pone.0005086

Fichter LS, Pyle EJ, Whitmeyer SJ (2010a). Expanding Evolutionary Theory Beyond Darwinism with Elaborating, Self-Organizing, and Fractionating Complex Evolutionary Systems. J Geo Edu 58: 58-64. https://doi.org/10.5408/1.3534853

Fichter LS, Pyle EJ, Whitmeyer SJ (2010b). Strategies and Rubrics for Teaching Chaos and Complex Systems Theories as Elaborating, Self-Organizing, and Fractionating Evolutionary Systems. J Geo Edu 58: 82-102. https://doi.org/10.5408/1.3534849

Filtchev S, Dimov V (2010). Comparison of specific sublingual immunotherapy to homeopathic therapy in children with allergic rhinitis. J Allergy Clin Immunol. DOI: https://doi.org/10.1016/j.jaci.2009.12.167

Fisher P (1991). Homeopathy in its home land. Br Homeopath J 80: 238-240. https://doi.org/10.1016/S0007-0785(05)80752-5

Fisher P (2010). Does homeopathy have anything to contribute to hormesis? Hum Exp Toxicol 29: 555-560. https://doi.org/10.1177/0960327110369776

Fodor J, Piattelli-Palmarini M (2011). What Darwin Got Wrong. London: Profile Books.

Frazer JW, Frazer JE (1987). The communication of molecules. Festschrift Celebrating the 65th Birthday of Lyndon LaRouche, Executive Intelligence Review, Wiesbaden, Germany, pp. 45-52.

Fröhlich H (1968). Long-range coherence and energy storage in biological systems. Int J Quantum Chem 2: 641-649. https://doi.org/10.1002/qua.560020505

Fröhlich H (1970). Long-range coherence and the actions of enzymes. Nature 228: 1093.

Fröhlich H (1975). The extraordinary dielectric properties of biological materials and the actions of enzymes. Proc Natl Acad Sci USA 72: 4211-4215. https://doi.org/10.1073/pnas.72.11.4211

Gammaitoni L, Hänggi P, Jung P, Marchesoni F (1998). Stochastic resonance. Rev Mod Phys 70: 223. https://doi.org/10.1103/RevModPhys.70.223

Gilbert SF, Opitz JM, Raff RA (1996). Resynthesizing evolutionary and developmental biology. Dev Biol 173: 357-72. https://doi.org/10.1006/dbio.1996.0032

Glancy J, Stone JV, Wilson SP (2016). How self-organization can guide evolution. R Soc open sci 3: 60553. https://doi.org/10.1098/rsos.160553

Glattfelder JB (2019). Information- Consciousness-Reality: How a New Understanding of the Universe Can Help Answer Age-Old Questions of Existence (The Frontiers Collection). Springer International Publishing: Kindle Edition. https://doi.org/10.1007/978-3-030-03633-1

Goodwin B (2020). How the Leopard Changed Its Spots: The Evolution of Complexity. Princeton, NJ: Princeton University Press. https://doi.org/10.2307/j.ctv14163sj

Goodwin BC (1987). Developing organisms as self-organizing fields. In: Yates FE (ed). Self-Organizing Systems. New York: Plenum Press, pp.167-180. https://doi.org/10.1007/978-1-4613-0883-6_10

Goodwin B, Sanders P (1992). Theoretical Biology: Epigenetic and Evolutionary Order from Complex Systems. Baltimore, Maryland: Johns Hopkins University Press. https://doi.org/10.2307/2532232

Goodwin BC, Webster G, Smith JW (1987). The 'evolutionary paradigm' and 'constructional biology'. Explorations in Knowledge 4: 29-40.

Gould SJ, Lewontin RC (1979). The spandrels of San Marco and the Panglossian paradigm: a critique of the adaptationist programme. Proc R Soc Lond B 205: 581-598. https://doi.org/10.1098/rspb.1979.0086

Green DM (1991). Chaos, fractals and nonlinear dynamics in evolution and phylogeny. Trends Ecol Evol 6: 333-7. https://doi.org/10.1016/0169-5347(91)90042-V

Gurfinkel YI, Voeikov VL, Buravlyova EV, Kondakov SE (2001). Effect of geomagnetic storms on the erythrocyte sedimentation rate in ischemic patient. Crit Rev Biomed Eng 29: 65-76. https://doi.org/10.1615/CritRevBiomedEng.v29.i1.20

Haehl R (2003). Samuel Hahnemann His Life and Work. New Delhi: B. Jain Publishers.

Hahnemann S (2013 edition). Organon of the Medical Art: Edited and annotated by O'Reilly, WB. Palo Alto: Birdcage Press.

Halley JD, Winkler DA (2008). Consistent Concepts of Self-organization and Self-assembly Wiley Periodicals Inc 14: 10-17, https://doi.org/10.1002/cplx.20235

Hartland A, Lead JR, Slaveykova VI, O'Carroll D, Valsami-Jones E (2013). The Environmental Significance of Natural Nanoparticles. Nature Education Knowledge 4: 7.

Henniker JC (1949). The depth of the surface zone of a liquid. Rev Mod Phys 21: 322-341. https://doi.org/10.1103/RevModPhys.21.322

Ho M-W (2007). The real bioinformatics revolution. Sci Soc 33: 42-45.

Ho M-W (2012). Living Rainbow H2O. Singapore: World Scientific Publishing Company. https://doi.org/10.1142/8418

Ho M-W (2014a). Illuminating Water and Life. Entropy 16: 4874-4891. https://doi.org/10.3390/e16094874

Ho M-W (2014b). Water is the means, medium & message of life. Int J Design & Nature and Ecodynamics 9: 1-12. https://doi.org/10.2495/DNE-V9-N1-1-12

Ho M-W. (2014c). Large supramolecular water clusters caught on camera - a review. WATER 6: 1-12. doi: 10.14294/WATER.2013.12

Ho M-W (2015). Illuminating water and life: Emilio Del Giudice. Electromagn Biol Med 34: 113-22. https://doi.org/10.3109/15368378.2015.1036079

Ho M-W, Yu-Ming Z, Haffegee J, Watton A, Musumeci F, Privitera G, Scordino A, Triglia A (2006). The Liquid Crystalline Organism and Biological Water. In: Pollack GH, Cameron IL, Wheatley DN (eds). Water and the Cell. Dordrecht: Springer, pp 219-234. https://doi.org/10.1007/1-4020-4927-7_10

Hoffmann AA, Hercus MJ (2000). Environmental Stress as an Evolutionary Force. BioScience 50: 217-226. https://doi.org/10.1641/0006-3568(2000)050[0217:ESAAEF]2.3.CO;2

Hoover TA (2020). What Future for Hahnemann's Therapeutic System? Homeopathy 109: 107-112. https://doi.org/10.1055/s-0039-3401013

Huang RC (2018). The discoveries of molecular mechanisms for the circadian rhythm: The 2017 Nobel Prize in Physiology or Medicine. Biomedical journal 41: 5-8. https://doi.org/10.1016/j.bj.2018.02.003

Huxley J (1942). Evolution: The Modern Synthesis. London: George Allen & Unwin Ltd.

Jabs H, Rubik B (2014). Self-Organization at Aqueous Colloid-Membrane Interfaces and an Optical Method to Measure the Kinetics of Exclusion Zone Formation. Entropy 16: 5954- 5975. https://doi.org/10.3390/e16115954

Johnson BR, Lam SK (2010). Self-organization, Natural Selection, and Evolution: Cellular Hardware and Genetic Software. BioScience 60: 879-885. https://doi.org/10.1525/bio.2010.60.11.4

Josephson BD (1992). The Elusivity of nature and the Mind-Matter Problem. In: Rubik B (ed). The Inter relationship Between Mind and Matter. Temple University: Center for Frontier Sciences, pp. 219-222.

Kanherkar RR, Stair SE, Bhatia-Dey N, Mills PJ, Chopra D, Csoka AB (2017). Epigenetic Mechanisms of Integrative Medicine. Evid Based Complement Alternat Med 2017:4365429. https://doi.org/10.1155/2017/4365429

Karsenti E (2008). Self-organization in cell biology: A brief history. Nature Reviews Molecular Cell Biology 9: 255-262. https://doi.org/10.1038/nrm2357

Katsnelson MI, Wolf YI, Koonin EV (2018). Towards physical principles of biological evolution. Phys Scr 9: 043001. https://doi.org/10.1088/1402-4896/aaaba4

Kauffman SA (1993). The Origin of Order: Self-organization and Selection in Evolution. Oxford: Oxford University Press.

Kayne SB (2006). Homeopathic pharmacy: theory and practice. 2nd ed, Elsevier Health Sciences. https://doi.org/10.1016/B978-044310160-1.50016-9

Keller EF (2005). Ecosystems, Organisms, and Machines. BioScience 55: 1069-1074. https://doi.org/10.1641/0006-3568(2005)055[1069:EOAM]2.0.CO;2

Kent JT (1986 reprint). Kent's New Remedies: Clinical Cases, Lesser Writings, Aphorisms and Precepts. New Delhi: Pratap Medical Publishers.

Kent JT (1990 reprint). Lectures of homoeopathic materia medica. New Delhi: Jain publishers.

Khuda-Bukhsh AR (2014). Current trends in high dilution research with particular reference to gene regulatory hypothesis. Nucleus 57: 3-17. https://doi.org/10.1007/s13237-014-0105-0

Kirchner JW (2002). THE GAIA HYPOTHESIS: FACT, THEORY, AND WISHFUL THINKING. Climatic Change 52: 391-408.

https://doi.org/10.1023/A:1014237331082

Kirschner M, Gerhart J, Mitchison T (2000). Molecular "vitalism". Cell 100: 79-88. https://doi.org/10.1016/S0092-8674(00)81685-2

Kokornaczyk MO, Würtenberger S, Baumgartner S (2020). Impact of succussion on pharmaceutical preparations analyzed by means of patterns from evaporated droplets. Scientific Reports 10: 570 https://doi.org/10.1038/s41598-019-57009-2

Konovalov AI, Ryzhkina IS (2014). Formation of nanoassociates as a key to understanding of physicochemical and biological properties of highly dilute aqueous solutions. Russ Chem Bull 63, 1-14. https://doi.org/10.1007/s11172-014-0388-y

Kučera O, Cifra M (2013). Cell-to-cell signaling through light: just a ghost of chance? Cell Commun Signal 11, 87 https://doi.org/10.1186/1478-811X-11-87

Kurakin A (2007). Self-organization versus watchmaker: Ambiguity of molecular recognition and design charts of cellular circuitry. Journal of Molecular Recognition 20: 205-214. https://doi.org/10.1002/jmr.839

Laland K, Uller T, Feldman M, Sterelny K, Müller GB, Moczek A, Jablonka E, Odling-Smee J, Wray GA, Hoekstra HE, Futuyma DJ, Lenski RE, Mackay TF, Schluter D, Strassmann JE (2014). Does evolutionary theory need a rethink? Nature 514: 161-4. https://doi.org/10.1038/514161a

Laland KN, Uller T, Feldman MW, Sterelny K, Mu¨ller GB, Moczek A, Jablonka E, Odling-Smee J (2015). The extended evolutionary synthesis: its structure, assumptions and predictions. Proc R Soc B 282: 20151019. https://doi.org/10.1098/rspb.2015.1019

Leggett JM (1997). Medical scientism: good practice or fatal error? J R Soc Med 90: 97-101. https://doi.org/10.1177/014107689709000213

Lenger K, Bajpai RP, Spielmann M (2014). Identification of unknown homeopathic remedies by delayed luminescence. Cell Biochem Biophys 68: 321-334. https://doi.org/10.1007/s12013-013-9712-7

Levin M (2003). Bioelectromagnetics in morphogenesis. Bioelectromagnetics 24: 295-315. https://doi.org/10.1002/bem.10104

Levin M (2011). The wisdom of the body: future techniques and approaches to morphogenetic fields in regenerative medicine, developmental biology and cancer. Regen med 6: 667-673. https://doi.org/10.2217/rme.11.69

Levin M (2012). Morphogenetic fields in embryogenesis, regeneration, and cancer: non-local control of complex patterning. Biosystems 109: 243-61. https://doi.org/10.1016/j.biosystems.2012.04.005

Li KH (1992). Coherence in physics and biology. In: Popp FA, Li KH, Gu Q (eds). Recent Advances in Biophoton Research and Its Applications. Singapore: World Scientific, pp. 113-155. https://doi.org/10.1142/9789814439671_0004

Li KH (1994). Uncertainty principle, coherence, and structures. In: Mishra RK, Maass D, Zwierlein E (eds). On Self-Organization. Berlin: Springer, pp. 245-255. https://doi.org/10.1007/978-3-642-45726-5_15

Li KH (1995). Coherence-a bridge between micro- and macrosystems. In: Belousov LV, Popp FA (eds). Biophotonics-Non-Equilibrium and Coherent Systems in Biology, Biophysics and Biotechnology. Moscow: Bioinform Services, pp. 99-114.

Linde K, Clausius N, Ramirez G, Melchart D, Eitel F, Hedges LV, Jonas WB (1997). Are the clinical effects of homoeopathy placebo effects? A meta-analysis of placebo-controlled trials. Lancet 350: 834-43. https://doi.org/10.1016/S0140-6736(97)02293-9

Ling G (2007). Nano-protoplasm: the ultimate unit of life. Physiol Chem Phys Med NMR 39: 111-234. Erratum in 2012: Physiol Chem Phys Med NMR 42: 115.

Ling, GN (1962). A Physical Theory of the Living State: the Association-Induction Hypothesis. Waltham, MA: Blaisdell.

Ling GN (2003). 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. Physiol Chem Phys & Med NMR 35: 91-130.

Ling GN (2012). What is life answered in terms of properties and activities of auto-cooperative assemblies of molecules, atoms, ions and electrons called nano-protoplasm. Physiol Chem Phys Med NMR 42: 1-64.

Liu L, Zhang Y, Wu S, Li S, Qin D (2018). Water memory effects and their impacts on global vegetation productivity and resilience. Scientific Reports 8: 2962. https://doi.org/10.1038/s41598-018-21339-4

Logan AC, Selhub EM (2012). Vis Medicatrix naturae: does nature "minister to the mind?" BioPsychoSocial Med 6:11. https://doi.org/10.1186/1751-0759-6-11

Loughlin M (2021). Science and Experience: Repairing a Fractured Medicine. Complement Med Res 28: 1-4. https://doi.org/10.1159/000511584

Lovelock J (2003). Gaia: The living Earth. Nature 426, 769-770. https://doi.org/10.1038/426769a

Lovelock JE (1979). Gaia: A New Look at Life on Earth. Oxford: Oxford University Press.

Luckey TD (1997). Radiation Hormesis. In: Bastide M (ed). Signals and Images. Dordrecht: Springer, pp. 31-39. https://doi.org/10.1007/978-94-011-5804-6_2

Luisi PL (2003). Autopoiesis: a review and a reappraisal. Naturwissenschaften 90: 49-59. DOI 10.1007/s00114-002-0389-9 https://doi.org/10.1007/s00114-002-0389-9

Manzalini A, Galeazzi B (2019). Explaining Homeopathy with Quantum Electrodynamics. Homeopathy 108: 169-176. https://doi.org/10.1055/s-0039-1681037

Marzotto M, Olioso D, Brizzi M, Tononi P, Cristofoletti M, Bellavite P (2014). Extreme sensitivity of gene expression in human SHSY5Y neurocytes to ultralow doses of Gelsemium sempervirens. BMC Complement Altern Med 19: 104. https://doi.org/10.1186/1472-6882-14-104

Mathie RT, Ramparsad N, Legg LA, Clausen J, Moss S, Davidson JR, Messow CM, McConnachie A (2017). Randomised, double-blind, placebo-controlled trials of non-individualised homeopathic treatment: systematic review and meta-analysis. Syst Rev 6: 63. https://doi.org/10.1186/s13643-017-0445-3

Mathie RT, Ulbrich-Zürni S, Viksveen P, Roberts ER, Baitson ES, Legg LA, Davidson JRT (2018). Systematic Review and Meta-Analysis of Randomised, Other-than-Placebo Controlled, Trials of Individualised Homeopathic Treatment. Homeopathy 107: 229-243. https://doi.org/10.1055/s-0038-1667129

Mattson MP, Calabrese EJ (2010a). Hormesis: A Revolution in Biology, Toxicology and Medicine. New York: Springer.

Mattson MP, Calabrese EJ (2010b). Hormesis: What It Is and Why It Matters. In: Mattson MP, Calabrese EJ, eds. Hormesis: A Revolution in Biology, Toxicology and Medicine. New York: Springer, pp. 1-13. https://doi.org/10.1007/978-1-60761-495-1_1

Maturana HR, Mpodozis J (2000). The origin of species by means of natural drift. Rev chil hist nat 73: 261-310. https://doi.org/10.4067/S0716-078X2000000200005

Maturana HR, Varela FJ (1987). The Tree of Knowledge: The Biological Roots of Human Understanding. Boston: Shambhala.

Mayburov S (2012). Photonic Communications and Information Encoding in Biological Systems. Cornell University: arxiv.org/abs/1205.4134 [q-bio.OT]

Mayr E (1988). Toward a New Philosophy of Biology: Observations of an Evolutionist. Cambridge: Harvard University Press.

Mayr E (2002) The Autonomy of Biology. Walter Arndt lecture. Available at http://www1.biologie.uni-hamburg.de › autonomy

McFadden J, Al-Khalili J (2018). The origins of quantum biology. Proc R Soc A 474: 20180674. https://doi.org/10.1098/rspa.2018.0674

Milgrom LR (2009). Gold standards, golden calves, and random reproducibility: Why homeopaths at last have something to smile about. J Altern Complement Med 15: 205-207. https://doi.org/10.1089/acm.2009.0071

Milgrom LR (2014). "Living is easy with eyes closed ..." on blinded RCTs and specific and non-specific effects of complex therapeutic interventions. Euro J Int Medicine 6: 552-559. https://doi.org/10.1016/j.eujim.2014.06.008

Milgrom LR (2020). Entelechy Regained? Further Musings on a Quantised Gyroscopic Metaphor for the Vital Force in Health and Disease. Complement Med Res 27: 6-18. https://doi.org/10.1159/000500903

Milgrom LR (2021). Against Scientism: Corrupted Science and the Fight for Medicine's Soul. Complement Med Res 28: 56-63. https://doi.org/10.1159/000510229

Misteli T (2007). Beyond the Sequence: Cellular Organization of Genome Function. Cell 128: 787-800. https://doi.org/10.1016/j.cell.2007.01.028

Montagnier L, Aissa J, Del Giudice E, Lavallee C, Tedeschi A, Vitiello G (2011). DNA waves and water. J Phys: Conf Series 306: 012007. https://doi.org/10.1088/1742-6596/306/1/012007

Montagnier L, Del Giudice E, Aïssa J, Lavallee C, Motschwiller S, Capolupo A, Polcari A, Romano P, Tedeschi A, Vitiello G (2015). Transduction of DNA information through water and electromagnetic waves. Electromagn Biol Med 34: 106-12. https://doi.org/10.3109/15368378.2015.1036072

Mudunkotuwa IA, Grassian VH (2011). The devil is in the details (or the surface): impact of surface structure and surface energetics on understanding the behavior of nanomaterials in the environment. J Environ Monit 13: 1135-44. https://doi.org/10.1039/c1em00002k

Musa S, Florea D, Van Loon S, Wyss H, Huyghe JM (2013). Interfacial Water: Unexplained Phenomena. Poromechanics V. American Society of Civil Engineers. https://doi.org/10.1061/9780784412992.246

Newman SA, Forgacs G, Muller GB. (2006). Before programs: The physical origination of multicellular forms. International J Developmental Biology 50: 289-299. https://doi.org/10.1387/ijdb.052049sn

Nicolis G, Prigogine I (1977). Self-organization in Nonequilibrium Systems: From Dissipative Structures to Order through Fluctuations. New York: Wiley & Sons.

Ogle K, Barber JJ, Barron-Gafford GA, Bentley LP, Young JM, Huxman TE, Loik ME, Tissue DT (2015). Quantifying ecological memory in plant and ecosystem processes. Ecol Lett 18: 221-235. https://doi.org/10.1111/ele.12399

Olioso D, Marzotto M, Bonafini C, Brizzi M, Bellavite P. (2016) Arnica montana effects on gene expression in a human macrophage cell line. Evaluation by quantitative Real-Time PCR. Homeopathy 105:131-147. https://doi.org/10.1016/j.homp.2016.02.001

Olioso D, Marzotto M, Moratti E, Brizzi M, Bellavite P (2014). Effects of Gelsemium sempervirens L. on pathway-focused gene expression profiling in neuronal cells. J Ethnopharmacol 153: 535-539. https://doi.org/10.1016/j.jep.2014.02.048

Olsen S (2017). Effects of ultra-high dilutions of sodium butyrate on viability and gene expression in HEK 293 cells. Homeopathy 106: 32-36. https://doi.org/10.1016/j.homp.2017.01.003

Opitz JM, Gilbert SF (1997). Commentary to Beloussov LV, Life of Alexander G. Gurwitsch and his relevant contribution to the theory of morphogenetic fields. Int J Dev Biol 41: 778.

Otsuka I, Ozeki S (2006). Does magnetic treatment of water change its properties? J Phy Chem B Lett 110: 1509-1512. https://doi.org/10.1021/jp056198x

Paul R (1983). Production of coherent states in biological systems. Phys Lett A 96: 263-268. https://doi.org/10.1016/0375-9601(83)90349-3

Pennisi E (2016). Templeton grant funds evolution rethink. Science 352:394-395. https://doi.org/10.1126/science

Piccardi G (1946). The 22 years of solar cycle and chemical tests. J Interdisciplin Cycl Res III 3: 4. https://doi.org/10.1080/09291017209359357

Piccardi G (1956). The influence of terrestrial, solar and cosmic phenomena on physical-chemical and biological reactions. Ciel et Terre 72: 551-564.

Piccardi G (1962). The Chemical Basis of Medical Climatology. Springfield, USA: Charles C. Thomas Publisher.

Pietak AM (2012). Structural evidence for electromagnetic resonance in plant morphogenesis. Biosystems 109: 367-80. https://doi.org/10.1016/j.biosystems.2012.01.009

Pigliucci M (2007). Do we need an extended evolutionary synthesis? Evolution 61:2743-2749. https://doi.org/10.1111/j.1558-5646.2007.00246.x

Pigliucci M, Müller GB (2010). Evolution: The Extended Synthesis. MIT Press.https://doi.org/10.7551/mitpress/9780262513678.001.0001

Podgórski JS (2010). Humberto Maturana's view on the theory of evolution. From autopoiesis to natural drift metaphor. Ecological Questions 13: 81 - 87. https://doi.org/10.2478/v10090-010-0019-7

Poitevin B (1999). Integrating homoeopathy in health systems. Bulletin of the World Health Organization 77: 160-166. https://www.who.int/bulletin/archives/77(2)160.pdf

Polani D (2009). Information: currency of life? HFSP J 3:307-316. https://doi.org/10.2976/1.3171566

Pollack GH (2001). Cells, Gels, and the Engines of Life. Seattle, Washington: Ebner and Sons Publishers.

Pollack GH (2013). The Fourth Phase of Water: Beyond Solid, Liquid, and Vapor. Seattle, Washington: Ebner and Sons Publishers.

Pollack GH, Figueroa X, Zhao Q (2009). Molecules, Water, and Radiant Energy: New Clues for the Origin of Life. Int J Mol Sci 10:1419-1429. https://doi.org/10.3390/ijms10041419

Popp FA, Gu Q, Li KH (1994). Biophoton emission: experimental background and theoretical approaches. Mod Phys Lett B 8: 1269-1296. https://doi.org/10.1142/S0217984994001266

Prasad R (2007). Homoeopathy booming in India. Lancet 370:1679-1680. https://doi.org/10.1016/S0140-6736(07)61709-7

Preethi K, Ellanghiyil S, Kuttan G, Kuttan R (2012). Induction of apoptosis of tumor cells by some potentiated homeopathic drugs: implications on mechanism of action. Integr Cancer Ther 11: 172-182. https://doi.org/10.1177/1534735411400310

Preparata G (1995). QED Coherence in Matter. Singapore: World Scientific. https://doi.org/10.1142/2738

Presman AS (1970). Electromagnetic Fields and Life. New York: Plenum. https://doi.org/10.1007/978-1-4757-0635-2

Prigogine I (1984). Order Out of Chaos. New York: Bantam.

Prokopenko M (2009). Guided self-organization. HFSP J 3: 287-289. https://doi.org/10.2976/1.3233933

Razeto-Barry P (2012). Autopoiesis 40 years Later. A Review and a Reformulation. Orig Life Evol Biosph. https://doi.org/10.1007/s11084-012-9297-y

Renati P (2020). Electrodynamic coherence as a bio-chemical and physical basis for emergence of perception, semantics, and adaptation in living systems. https://doi.org/10.20944/preprints202011.0686.v1

Rey L (2003). Thermoluminescence of ultra-high dilutions of lithium chloride and sodium chloride. Physica A 323: 67-74. https://doi.org/10.1016/S0378-4371(03)00047-5

Rouleau N, Dotta BT (2014) Electromagnetic fields as structure-function zeitgebers in biological systems: environmental orchestrations of morphogenesis and consciousness. Front Integr Neurosci 8: 84. https://doi.org/10.3389/fnint.2014.00084

Rowlands S (1988). The interaction of living red blood cells. In: Fr¨ohlich H (ed). Biological Coherence and Response to External Stimuli. Berlin: Springer, pp. 171-191. https://doi.org/10.1007/978-3-642-73309-3_10

Ryzhkina IS, Murtazina LI, Konovalov AI (2011). Action of the external electromagnetic field is the condition of nanoassociate formation in highly diluted aqueous solutions. Doklady Phys Chem 440: 201-204. https://doi.org/10.1134/S0012501611100058

Saha SK, Roy S, Khuda-Bukhsh AR (2015). Ultrahighly diluted plant extracts of Hydrastis canadensis and Marsdenia condurango induce epigenetic modifications and alter gene expression profiles in HeLa cells in vitro. J Integr Med 13: 400-11. https://doi.org/10.1016/S2095-4964(15)60201-1

Saha T, Galic M (2018). Self-organization across scales: from molecules to organisms. Phil. Trans. R. Soc. B 373: 20170113. https://doi.org/10.1098/rstb.2017.0113

Schrodinger E (2013 reprint). What is life? With mind and matter & autobiographical sketches. Cambridge University Press.

Schulte J, Endler PC (2015). Update on preliminary elements of a theory of ultra high dilutions. Homeopathy 104: 337-42. https://doi.org/10.1016/j.homp.2015.09.010

Schulz H (1887). ZurLehre von der Arzneiwirdung. Virchows Arch Pathol Anat Physiol Klin Med 108: 423-445. https://doi.org/10.1515/9783112369043-025

Seddon AW, Macias-Fauria M, Long PR, Benz D, Willis KJ (2016). Sensitivity of global terrestrial ecosystems to climate variability. Nature 531: 229-232. https://doi.org/10.1038/nature16986

Sejdić E, Lipsitz LA (2013). Necessity of noise in physiology and medicine. Comput Methods Programs Biomed 111: 459-70. https://doi.org/10.1016/j.cmpb.2013.03.014

Şeker S, Güven C, Akçakaya H, Bahtiyar N, Akbaş F, Onaran İ (2018). Evidence that Extreme Dilutions of Paclitaxel and Docetaxel Alter Gene Expression of In Vitro Breast Cancer Cells. Homeopathy 107: 32-39. https://doi.org/10.1055/s-0037-1618585

Shapiro J A (1997). Genome organization, natural genetic engineering and adaptive mutation. Trends Genet 13: 98-104. https://doi.org/10.1016/S0168-9525(97)01058-5

Shapiro J A (2014). Physiology of the read-write genome. J Physiol 592: 2319-2341. https://doi.org/10.1113/jphysiol.2014.271130

Sherr J (2012). The Noble Gases: the starry night of Helium. Interhomeopathy. www.interhomeopathy.org

Sherr J (2013). Helium: Including an Introduction to the Noble Gases. Saltire Books.

Smith CW (1994). Electromagnetic and magnetic vector potential bioinformation and water. In: Endler PC, Schulte J (eds). Ultra High Dilution. Dordrecht: Kluwer Acad. Publ., pp. 187-201. https://doi.org/10.1007/978-94-015-8342-8_17

Smith CW (2004). Quanta and coherence effects in water and living systems. J Altern Complement Med 10: 69-78. https://doi.org/10.1089/107555304322848977

Smith CW (2008). The electrical properties of high dilutions. Homeopathy 97: 111-112. https://doi.org/10.1016/j.homp.2008.06.001

Smith CW (2015). Electromagnetic and magnetic vector potential bio-information and water. Homeopathy 104: 301-4. https://doi.org/10.1016/j.homp.2015.08.006

Smith KF, Goldberg M, Rosenthal S, Carlson L, Chen J, Chen C, Ramachandran S (2014). Global rise in human infectious disease outbreaks. J R Soc Interface 11: 20140950. https://doi.org/10.1098/rsif.2014.0950

Stebbing ARD (1982). Hormesis- The stimulation of growth by low levels of inhibitors. Science Total Environment 22: 213-234 https://doi.org/10.1016/0048-9697(82)90066-3

Stebbing ARD (1998): A theory for growth hormesis. Mutat Res 403: 24-258. https://doi.org/10.1016/S0027-5107(98)00014-1

Sthijns MM, Weseler AR, Bast A, Haenen GRMM (2016). Time in Redox Adaptation Processes: From Evolution to Hormesis. Int J Mol Sci 17: 1649. https://doi.org/10.3390/ijms17101649

St-Pierre LS, Mazzuchin A, Persinger MA (2008). Altered blood chemistry and hippocampal histomorphology in adult rats following prenatal exposure to physiologically-patterned, weak (50-500 nano Tesla range) magnetic fields. Int J Radiat Biol 84: 325-335. https://doi.org/10.1080/09553000801953300

St-Pierre LS, Parker GH, Bubenik GA, Persinger MA (2007). Enhanced mortality of rat pups following inductions of epileptic seizures after perinatal exposures to 5 nT,7 Hz magnetic fields. Life Sci 81: 1496-1500. https://doi.org/10.1016/j.lfs.2007.09.013

Sunila ES, Kuttan R, Preethi KC, Kuttan G (2009). Dynamized preparations in cell culture. Evid Based Complement Alternat Med 6: 257-263. https://doi.org/10.1093/ecam/nem082

Szent-Gyorgyi A (1956). Bioenergetics. Science 124: 873-875. https://doi.org/10.1126/science.124.3227.873

Szent-Gyorgyi A (1957). Bioenergetics. New York: Academic Press.

Tedeschi A (2010). Is the living dynamics able to change the properties of water? Int J Des Nat Ecodyn 5: 60-67. https://doi.org/10.2495/DNE-V5-N1-60-67

Teixeira MZ (2020). Correlation between Vitalism and Genetics According to the Paradigm of Complexity. Homeopathy 109: 30-36. https://doi.org/10.1055/s-0039-1692162

Teut M (2001). Homeopathy between Vital Force and Self-Organization. Forsch Komplementärmed Klass Naturheilkd 8: 162-167. https://doi.org/10.1159/000057213

Thorp KE (2021). Morphogenic fields: A coming of age. Explore (NY) 7: S1550-8307(21)00078-1. https://doi.org/10.1016/j.explore.2021.04.002

Tosi M, Del Giudice E (2013). The principle of minimal stimulus in the dynamics of the living organism. Sci Soc 60: 26-29.

Trukhan EM, Anosov VN (2007). Vector potential as a channel of informational effect on living objects. Biofizika 52: 376-381

Ullman D (2007). The Homeopathic Revolution: Why Famous People and Cultural Heroes Choose Homeopathy. Berkeley, California: North Atlantic Books.

Ullman D (2021). Exploring Possible Mechanisms of Hormesis and Homeopathy in the Light of Nanopharmacology and Ultra-High Dilutions. Dose-Response 19: 15593258211022983. https://doi.org/10.1177/15593258211022983

Upadhyay RP (2002). Homeopathy and quantum vacuum. Homeopathy 91: 268. https://doi.org/10.1054/homp.2002.0063

Upadhyay RP (2005). Homeopathy: Problems & their remedies with future. Silver Jubilee & Seminar on Fundamental and Evidenced Based Clinical Research-CCRH souvenir, New Delhi, India pp. 70-73.

Upadhyay RP (2017). The possible mechanism of memory through nanoparticles and exclusion zones. WATER 7: 158-176. DOI 10.14294/WATER.2016.4

Upadhyay RP (2018). The Materialist View of Homeopathy: An Alternative Hypothesis and the Connection with Hormesis. Homeopathy 107: 46-49. https://doi.org/10.1055/s-0037-1617760

Upadhyay RP (2019). Nanoscience Study of homeopathic Medicine. Homeopathy 108: 71-72. https://doi.org/10.1055/s-0038-1675820

Upadhyay RP (2020). Earliest Medicines Evolved from Dangerous Environmental Stressors to Support Life on a Hostile Earth: A Nanoparticle and Water-based Evolutionary Theory. WATER 11: 55-77. DOI 10.14294/WATER.2019.7

Upadhyay RP, Nayak C (2011). Homeopathy emerging as nanomedicine. Int J High Dilution Res 10: 299-310. https://doi.org/10.51910/ijhdr.v10i37.525

Van de Vijver G (2006). Kant and the Intuitions of Self-Organization. In: Ffltz B, Crommelinck M, Goujon P (eds) Self- Organisation and Emergence in Life Sciences. Dordrecht: Springer, pp. 143-161. https://doi.org/10.1007/1-4020-3917-4_9

Van Wijk R (2001). Bio-photons and Bio-communication. J Scientific Exploration 15: 183-197.

Van Wijk R, Wiegant FA (2010). Post conditioning hormesis and the homeopathic Similia principle: molecular aspects. Hum Exp Toxicol 29: 561-565. https://doi.org/10.1177/0960327110369860

Varela FJ (1979). Principles of Biological Autonomy. New York: Elsevier/North-Holland.

Vicsek, T (2002). Complexity: The bigger picture. Nature 418, 131. https://doi.org/10.1038/418131a

Vithoulkas G (1993 reprint). The Science of Homeopathy. New Delhi: B. Jain Publishers.

Vitiello G (2001). My Double Unveiled. Amsterdam: John Benjamins. https://doi.org/10.1075/aicr.32

Vitiello G (2008). Topological defects, fractals and the structure of quantum field theory. arXiv:0807.2164 [hep-th]

Vitiello G (2012). Fractals as macroscopic manifestation of squeezed coherent states and brain dynamics. J Phys: Conf Ser 380: 012021. https://doi.org/10.1088/1742-6596/380/1/012021

Vitiello G (2014). On the Isomorphism between Dissipative Systems, Fractal Self-Similarity and Electrodynamics. Toward an Integrated Vision of Nature. Systems 2: 203-216. https://doi.org/10.3390/systems2020203

Voeikov VL (2015) Progressive Evolution - the inherent property of aquous systems. Water Conference, Varna, Bulgaria. https://istina.msu.ru/conferences/presentations/12273505/

Voeikov VL, Del Giudice E (2009). Water Respiration - The Basis of the Living State. WATER 1: 52 - 75.

Voeikov VL, Ming HD, Mukhitova OG, Vilenskaya ND, Malishenko SI, Bogachuk AS (2010). Activated bicarbonate solutions as models of confined ontic open systems and prototypes of living respiring systems. Int J Des Nat Ecodyn 5: 30-38. https://doi.org/10.2495/DNE-V5-N1-30-38

Waisse S, Bonamin LV (2016). Explanatory models for homeopathy: from the vital force to the current paradigm. Homeopathy 105: 280-285. https://doi.org/10.1016/j.homp.2016.02.003

Wedlich-Soldner R, Betz T (2018). Self-organization: the fundament of cell biology. PhilTrans R Soc B 373: 20170103 https://doi.org/10.1098/rstb.2017.0103

Weiss P (1939). Principles of Development. New York: Holt.

Welch JJ (2017). What's wrong with evolutionary biology? Biol Philos 32:263-279. https://doi.org/10.1007/s10539-

016-9557-8

Whitmont EC (1991). Psyche and Substance: Essays on Homeopathy in the Light of Jungian Psychology. Berkeley, California: North Atlantic Books.

Whitmont EC (1993). The Alchemy of Healing: Psyche and Soma. Berkeley, California: North Atlantic Books.

Wiegant F, Van Wijk R (2010). The similia principle: results obtained in a cellular model system. Homeopathy 99: 3-14. https://doi.org/10.1016/j.homp.2009.10.002

Wills PR (2009). Informed generation: Physical origin and biological evolution of genetic code script interpreters. J Theoretical Biology 257: 345-358. https://doi.org/10.1016/j.jtbi.2008.12.030

Yakhno TA, Yakhno VG (2018). On the interaction of water with hydrophilic surfaces. Russ J Biol Phys Chem 3: 9-18.

Yinnon TA (2018). Aqueous Solutions and other Polar Liquids Perturbed by Serial Dilutions and Vigorous Shaking: Analyses of Their UV Spectra. WATER 10: 11-40. DOI: 10.14294/2018.5

Yinnon TA (2020). Liquids Prepared by Serially Diluting and Vigorously Shaking of Aqueous Solutions: Unveiling Effects of the Solute on their Properties. WATER 10: 115-134. DOI: 10.14294/2019.2

Zee A (2010). Quantum Field Theory in a Nutshell - Second Edition. Princeton: Princeton University Press.

Zeiger B, Bischof M (1998). The quantum vacuum in biology. Proceedings of the 3rd International Hombroich Symposium on Biophysics. Neuss, Germany

Zhang H, Gilbert B, Huang F, Banfield JF (2003). Water-driven structure transformation in nanoparticles at room temperature. Nature 424:1025-1029. https://doi.org/10.1038/nature01845

Zheng J-M, Chin W-C, Khijniak E, Khijniak E Jr., Pollack GH (2006). Surfaces and interfacial water: evidence that hydrophilic surfaces have long-range impact. Advances in Colloid and Interface Science 127: 19-27. https://doi.org/10.1016/j.cis.2006.07.002

Web References

1. Information in Water: Pollack Laboratory https://www.pollacklab.org/research [accessed on 24 February 2020].

2. https://www.brainyquote.com/quotes/albert_szentgyorgyi_385453 [accessed on 08 July 2020].

3. Paracelsus. Biography & Facts. https://www. britannica.com/biography/Paracelsus [accessed on 14 April 2020].

4. www.nobelprize.org › prizes › medicine › behring › facts [accessed on 08 June 2020]

5. Complex adaptive systems - The Health Foundation www.health.org.uk [accessed on 01 May 2020].

6. Biophoton Communication: Can Cells Talk Using Light? | MIT Technology Review https://www.technologyreview.com › 2012/05/22 › [accessed on 03 May 2021]

7. Brownell L (2019). Mike Levin on electrifying insights into how bodies form. Posted July 26, 2019. WYSS Institute https://wyss.harvard.edu/news/mike-levin-on-electrifying-insights-into-how-bodies-form/ [accessed on 12 August 2021].

8. The Editors of Encyclopaedia Britannica. "Gaia hypothesis". Encyclopedia Britannica, 31 March 2019, https://www.britannica.com/science/Gaia-hypothesis. [accessed on 14 August 2021].

9. Homeopathic drugs modify gene expression in cancer cells. Published online 23 November 2015, https://www.natureasia.com/en/nindia/article/10.1038/nindia.2015.154 [accessed on 28 August 2021]

10. Homeopathy Research Institute. The Swiss HTA report on homeopathy. Available at: https:// www.hri-research.org/resources/homeopathy-the-debate/the-swiss-hta-report-on-homeopathy/. [accessed on 03 August 2020]

11. https://en.wikipedia.org/wiki Category:Drugs_with_unknown_mechanisms_of_action [accessed on 12 April 2020]

12. World Health Organization. Nutrition and Global Burden of Chronic Disease. Available at: https://www.who.int/nutrition/ topics/2_background/en/. [accessed on 30 March 2020]

13. www.who.int>Newsroom>Fact sheets>Antibiotic resistance [accessed on 05 September 2020].