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High Dilution Effects on Cells and Integrated Systems

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COHERENCE IN BIOLOGICAL SYSTEMS AND WATER

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ABSTRACT

The concept of coherence in biological systems is introduced and related to electromagnetic theory, energetics and the dimensions of systems, and to bio-information. The phenomenon of coherence in water is considered with its thresholds and limits. This is related to the properties of water "memory".

1. Introduction to Coherence in Biological Systems

It is now clear that coherent frequencies of non-ionizing radiation from the sub-Hertz of circadian rhythms to at least the ultraviolet of bio-photons are involved in biological systems. There are various techniques available for the detection and measurement of bio-electromagnetic fields and the coherent frequencies and the patterns of frequencies generated by biological systems. The frequency "window" is the most important "window" for biological systems. With most biological systems and materials, the lowest and highest of the coherence frequencies are stimulatory, between these, depressive and stimulatory frequencies alternate. There are a few exceptions to this alternation of stimulatory and depressive response. There is also an intensity "window", for this the lower threshold may correspond to that magnetic field at which a single quantum of magnetic flux links the cross-sectional area of a biological cell, and the upper intensity threshold may correspond to that field sufficient to break the coherence.

Frohlich showed that a dielectric material polarized electrically acquires an energy dependent upon its shape and that deformation of the material will cause an electrical energy change, positive or negative, together with a change in the elastic energy which is always positive for a material previously in equilibrium. Interaction between electrical and elastic displacements leads to the establishment of metastable highly polarized states. He also remarked that magnetic flux quantization is not restricted to superconductors but, is a general property of all materials although, in the usual energy distributions single flux quanta phenomena do not appear due to the small energy differences in neighbouring flux quantum numbers. However, if a system is able to respond to the magnetic flux quantum then it will also have the Josephson effect available.

2. Electromagnetic Theory

Electric charge at rest exhibits the properties of static electricity: attraction and repulsion, the formation of chemical bonds. Electric charge moving at a constant velocity additionally gives rise to magnetism (a very second-order effect based on relativity theory). Electric charge under acceleration radiates energy into space as a transverse electromagnetic wave travelling at the velocity of light.

A wire carrying an electric current generates a magnetic field (B webers/m²) as closed loops of magnetic flux (F webers) in the space around the wire at right angles to the direction of the current (i amps). Associated with this current is a magnetic vector potential (A webers/m) in the direction of the current which can influence the "wave function" of electrons. A changing magnetic vector potential generates an electric field. A good article on understanding electromagnetic field theory has been written by Carpenter [1], who instead of using Maxwell's equations and the concept of flux, starts from electric and magnetic potentials.

The geometry of a magnetic field is determined by the way that the wire carrying the current is wound into a coil. If it is wound as a long solenoid this will generate a uniform magnetic field (B) inside the solenoid. There will be both B and A components in the space surrounding it. A toroid contains the B component completely within the coil but generates an A component in the surrounding space. A Möbius loop cancels out both the B and A components and does not potentise water. The Helmholtz coil arrangement (2 equal coils separated by their radius) gives a very uniform field (B) at the centre, close to the axis.

3. Energetics

There has been much progress in understanding the scientific fundamentals of the ways that living systems use and are influenced by electromagnetic fields. In physics, the size of regions within which collective action can be effective can be estimated from considerations of the physical energy involved. Energy calculations only depend on the initial and final energy states and are independent of the physical processes by which this is achieved. For a field to be effective in establishing any order, it must be able to overcome the randomising effect of thermal fluctuations. The energy contained in a field is proportional to the volume it occupies. Equating the energy in the field to the thermal energy gives the threshold volume within which the field can impose its order. The cube-root of this volume gives an idea of its linear dimensions [2]. An electromagnetic field comprises both electric and magnetic field components which are mutually at right angles as well as both being at right angles to the direction in which they propagate, at the

velocity of light. From these components the incident power density (joules/sec/m² or watts/m²) can be calculated and also related to the critical dimensions which can be ordered by incoming radiation.

For atomic dimensions (0.1 nm, 1 Å), the theoretical threshold electric field is above 10⁹ V/m, the order of field used in field emission microscopy to break chemical bonds; a whale (10 m long) can sense electric fields of about 1 μV/m, which is approaching its theoretical threshold. The geomagnetic field ought to be significant to single biological cells, and certain (magnetotactic) bacteria do make use of it. The corresponding theoretical threshold for effects of radiation on a single biological cell comes out equal to the 100 W/m², which is a guideline level for incident non-ionising radiation based on thermal effects, because of course, both calculations are based on the same fundamental criterion. Any bio-effects observed at weaker fields must be due to cooperative sensing and action within multi-cellular organisms. Oscillations both in chemical reactions and electrical charges are a natural phenomenon in living systems [3], and both can be affected by external electromagnetic fields.

Thus, if a system is physically large and well organised like a radio-telescope, very small energy fields can theoretically be detected by it, particularly if there is an energy store and one is prepared to wait long enough. Then, very small densities of incident power (*energy per second*) can accumulate until enough energy is available to produce an effect. A signal integrates in proportion to exposure time, the noise is proportional to the square-root of time, so the signal-to-noise ratio improves as the square-root of the integration time.

4. Bio-Information and Coherence

Every physical system contains both pure energy and pure information. Even the high energy, hot gases in the cylinders of a car engine carry information as to their chemical constituents and temperature. Biological systems operate in water at temperatures little different from ambient, so they cannot be powered thermally (like a steam engine). They use the *Free Energy* changes resulting from chemical reactions. The structure and function of biological systems is determined by very specific and closely regulated biochemical reactions which are controlled by enzymes (catalysts). Living cells can do work because they do not attain a state of equilibrium; the thermal equilibrium state is one of no work, a passive state. Only systems that are not in equilibrium can be subjected to control or regulation of their work activity.

For the meaningful control or regulation of any system, and this includes its repair or healing, some degree of order or coherence must pre-exist within it in space and time. At its simplest, the term *coherence* means that two or more separate oscillators maintain a constant phase relationship (i.e. they march in step) for a prolonged period of time (the

coherence time). If their oscillations propagate as waves, there will be a distance (equal to the velocity multiplied by the coherence time) over which this constant-phase relationship is found. This is the coherence length, and within it wave interference effects are found.

Any physical process which coherently controls a chemical reaction must be operating within "quantum" physics because there is no chemistry in "classical" physics. This statement must exclude such general parameters as temperature, pH, or pressure, which may affect the general activity of an ensemble of chemically reacting molecules through incoherent (time-averaged) information without providing control at the level of coherent molecules. "Biological coherence and response to external stimuli" has been the subject of a book edited by Fröhlich [4]. He considered that long-range phase correlations can give rise to the sort of order present in superconductors, super-fluid helium, and lasers. Living systems can achieve the necessary degree of coherence in the ground state so, they can behave as room-temperature superconductors, sensitive to single quanta of magnetic flux. Thus, they would acquire the frequency-voltage interconversion (500 MHz/μV) provided by the Josephson effect even though they would not exhibit the zero resistance and superfluidity phenomena of low-temperature superconductivity [5].

In the absence of any convincing theoretical explanation for the effects of weak electromagnetic fields on biological systems, it is difficult even to try to determine the thresholds for observed effects. Since any electric field must be generated across a capacitance, the displacement current will produce magnetic effects. Magnetic fields are generated by currents in coils and in the direction of the current there is a magnetic vector potential. A high alternating electric field produced at a sharp point would not potentise water even on succussion so, it is unlikely that the induced electric field $E = -dA/dt$ is involved. The only other way a magnetic vector potential can affect water or a biological system is through its involvement in the wave equation or order parameter of what must be regarded as a quantum system.

5. Coherence in Water

Water is essential for life as we know it and, water from certain sources has had healing properties attributed to it from ancient times. The water in a living cell is highly structured [6] and mostly does not exchange by diffusion. Ice can form in crystals orientated to a magnetic field which is evidence of magnetic effects on spatial long-range order in supercooled water [7]. Water is a liquid and its ordering must be in the time domain. Del Giudice and Preparata and co-workers [8] have continued to investigate the Quantum Electro Dynamics (QED) of various systems in 'Condensed Matter Physics' and, in particular, they have examined the dynamics of the rotational levels of water molecules. This requires the solution of the Schrödinger Wave Equation coupled with the Maxwell Electromagnetic Equations and leads to a model for liquid water which is a condensed vapour, rather than a molten solid.

E. Del Giudice [9,10] has presented in simple language an outline of the conceptual breakthrough by G. Preparata. In the course of a general programme of research on the coherent dynamics of matter, Preparata was able to show that the universally accepted quantum theory of gauge fields applied to quarks shows that they have a collective existence and the property of being non-isolatable. In condensed matter, which includes liquids and living systems, the relevant gauge field is the electromagnetic field. The quanta of these fields can interfere positively among themselves so that the particles move within a self-produced and self-trapped electromagnetic field of minimum energy in the ground state. This always occurs for quarks and may extend to higher levels. This is not the result of excitations in a far-from equilibrium dissipative system, the coherence is fundamental.

It seems that the bio-information is carried on the alternating magnetic vector potential while the magnetic field performs a formatting function [2,3]. This means that bio-information exists at the quantum level. It is clear that the "window" of frequency is the most important, the intensity "window" has a lower threshold which has been found to correspond to the magnetic field at which a single quantum of magnetic flux links the cross-sectional area of the biological cell. The upper threshold is probably that field which is sufficient to break the coherence of the system.

According to QED, water consists of two distinct intermixed phases; incoherent water molecules and clusters of coherent water molecules or domains about 75 nm in size, which act coherently towards any electromagnetic field, internal or external. These domains are stable against thermal agitation because of an energy gap of 12.06 eV against which the room temperature thermal energy of 1/40 eV has little effect. This model can account for the anomalies in the physical properties of water and in general can provide a theoretical foundation to the "flickering" hydrogen-bonded network of water molecules envisaged by Linus Pauling.

Water coherence can be destroyed by strong enough fields or by vaporization. As a simple example, Del Giudice originally considered the 50 cm^{-1} , 1.5 THz resonance ($1 \text{ THz} = 1 \text{ TeraHertz} = 1 \times 10^{12} \text{ Hz}$) in water, which is to be seen in Raman scattering and in neutron experiments [11]. This gives a coherent domain of $100 \mu\text{m}$, which would comprise 10^{17} water molecules in coherent oscillation. The number of water molecules that could be involved in a quantum fluctuation that would not break the coherence is the square root of this figure, ie. 3×10^7 water molecules. For radiation to interact with coherent water, it has to give its energy not to a single water molecule, but to the whole mass of 3×10^8 molecules. As a result, the 1.5 THz oscillation slows down to 5 kHz and the field develops a longitudinal component. Subsequent work has suggested that the 12.06 eV energy gap in water is more fundamental. This gives the smallest size for a coherence domain as 75 nm, although the $100 \mu\text{m}$ coherence domain may be superimposed.

6. Water "Memory"

Water can be 'imprinted' with a frequency using an alternating magnetic field, or with an alternating magnetic vector potential plus either succussion (a mechanical shock wave or a vortex) or a strong magnetic field. Water will slowly acquire an imprint by contact with a sample of imprinted water or metal; the higher frequencies imprint more quickly than the lower frequencies.

The instrumental detection of coherence frequencies in water has been achieved (but, with problems of repeatability) using a technique whereby a pair of gold wire electrodes is dipped into a cuvette containing the sample of 'frequency imprinted' water. These electrodes are connected to a low-noise, high-gain, narrow-band amplifier, or to a Fourier Transform Spectrometer with signal averaging over a large number of measurements. The frequencies measured in this way were the same as those originally 'imprinted' into the water and the same as those measured by a subjective method.

7. Thresholds and Limits to Coherence

As a result of this work, much is now known about how to erase 'water memory', albeit as the result of trying to measure erased samples. Heating water above 70°C will erase its memory, as will an inter-electrode current greater than about a microamp, or even the tube being handled by the 'wrong' person. But, most importantly, placing the water in a hypomagnetic container (e.g. a closed mu-metal box) erases not only 'water memory' but will also erase potentiated medicaments (both liquids and lactose tablets). The threshold steady magnetic field necessary for the maintenance of 'water memory' is about 400 nT. At this field, the mean separation between magnetic flux quanta ($2.07 \times 10^{-15} \text{ Wb}$) is $71 \mu\text{m}$. A strong magnetic field ($>250 \mu\text{T}$) must only suppress 'water memory' effects, because, in this case the original 'imprint' is recoverable by succussion. The 'imprinted' resonances in water will propagate as waves of coherence (Wüst Waves). They will not propagate through water in tubes of 2mm diameter or less. Insulated wires can be arranged to conduct a coherence wave from 'imprinted' water and by this means, one can provide the basic arrangement for an Aharonov and Bohm experiment, which does work. These above figures indicate some of the critical conditions for the coherence.

8. Conclusions

It is difficult but, essential to try to determine the thresholds for macroscopic coherence effects. Since any electric field must be generated across a capacitance, the displacement current will produce magnetic effects. Magnetic fields are generated by currents and in

the direction of the current there is a magnetic vector potential. There is the possibility of coherent frequencies of alternating magnetic vector potential fields affecting biological systems both directly, and through the imprinting of the biological systems environmental water 'memory'. The magnetic vector potential can affect water or a biological system through the wave equation or order parameter. This carries the implication that a biological system must be regarded as a macroscopic quantum system, and that bio-information is modulated on to a coherent frequency.

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WATER AND THE DIAGNOSIS AND TREATMENT OF ELECTROMAGNETIC HYPERSENSITIVITY

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ABSTRACT

The clinical effects of coherence relate particularly to electrically hypersensitive patients. These are persons who usually have some chemical damage, and in whom one or more regulatory systems are on the verge of instability. Very weak EM fields or water 'imprinted' with their appropriate frequency can take them from stability to instability or vice versa. Water "memory" can be imprinted with an alternating magnetic field, an alternating magnetic vector potential or, by a person holding and/or succussing a glass tube of water. The latter forms the basis of a technique for determining the stabilising and de-stabilising frequencies for patients too sensitive to be exposed to any coherent frequency.

1. Coherence and EM Hypersensitivity

This clinical work has been going on continuously since 1982, when Dr. Jean Monro asked whether I could do anything to help her with her electrically sensitive allergy patients [1,2]. Initially, we found that we needed to test these patients in a chemical and particulate clean environment, with coherent alternating magnetic fields at strengths of the order of 30 nT in the ELF, typical of those to be found in the environment. Eventually we found that we needed to cover frequencies ranging from millihertz to gigahertz. We began by observing the various patients' reactions and noted down their observed and reported symptoms. These turned out to be the same as the symptoms produced in them by chemical, food, or inhalant challenges and were in general characteristic of the individual patients rather than some particular electrical frequency. We sought those frequencies which had a therapeutic effect, in that when they were present in the environment the patients' symptoms disappeared.

When a biological system is measured over a wide range of frequencies, the coherent frequencies found are not regularly spaced like the harmonics of a musical instrument or an inductance-capacitance circuit but, fit better to a fractal equation. There are stimulating frequencies which are therapeutic and these seem to be able to speed up and synchronise the activity of biological systems. They alternate with depressing frequencies, the persistent presence of which paralyses the small frequency jumps in the coherence frequencies which seem to be naturally present in living systems. Exposure to a

depressing frequency is most unpleasant and quickly leads to a strong urge to "get-away" from it.

2. Diagnosis

2.1. Problems in Diagnosis

Difficulties were soon encountered. Many patients would have severe reactions at some frequency during test which for clinical reasons these must be avoided if at all possible. These might occur at any coherent frequency to which a patient happened to be sensitive, but, the frequency at which this might occur was not apparent until the patient started to react during testing. One had some indication of likely levels of patient sensitivity from the results of chemical and particulate testing which, had usually taken place before electrical testing was considered necessary. In particular, the tester needs advance warning if the patient had any tendency to anaphylaxis, or cardiac or respiratory problems, so that appropriate preventative measures can be taken. Testing electrically hypersensitive patients is a clinical procedure, it is not to be undertaken without medically qualified assistance and the ready availability of resuscitation facilities.

2.2. Water in Diagnosis

Some patients develop delayed reactions that come on hours, or even days, after the initial electrical challenge. A technique was needed that was not restricted to those patients who were either not very ill, or to those who reacted to an electrical challenge within seconds. To be able to help these other patients, I borrowed from the techniques of radiesthesia [3].

Furthermore, some patients did not have a body field strong enough to be detected. In this case, there is usually at least one coherent frequency in the theta (4-7 Hz) or delta (below 4 Hz) brain-wave region which will re-establish a "normal" body field pattern when the patient is exposed to it. This is conveniently done by having the patient hold a tube of water which has been 'imprinted' with the required frequency. The patient should then develop a strong enough body field for testing to be possible. This may be done by direct challenge with coherent frequencies, or by surrogate testing having the patient imprint a tube of water by succussion and subsequently measuring it.

2.3. Water in Therapy

As a result of clinical necessity, water was found to be capable of retaining the frequency information of an alternating magnetic field in a form which could be used therapeutically. This came about when Dr. Monro and I first encountered a patient who needed a therapeutic frequency in the microwave region; it was not practicable to supply the patient with a microwave oscillator. The empirical rule for therapy of electromagnetic

hypersensitivity is to use an oscillator at one of the highest stimulatory frequencies found or, to imprint some or all of the stimulating frequencies into water and to use this as a medicament. The imprinting is easily done by succussing a thick and tough glass tube half filled from any source of water that the patient can tolerate, on a wooden surface next to a coil fed from an oscillator at the required frequency. The strength of the oscillation is not critical over a very wide range. To succuss the tube, it should be held above the water level so that the tester's body fields are not imprinted along with the frequency imprint, and given sharp rap on the wooden surface but, not hard enough to break the glass.

If a sample of 'imprinted' water is placed on one side of a toroid excited by an alternating current, and a sample of 'clean' water is placed equidistant on the other side and succussed, the latter acquires a phase-inverted imprint of the original water. A practical application for this is in allergy or surrogate electromagnetic hypersensitivity therapy since, it provides a way of inverting the phase of frequency components of allergens outside the available bandwidths of electrotherapy or electroacupuncture apparatus. That is, it can convert depressive frequency imprints into stimulatory ones.

It seems that the above techniques act by stimulating the autonomic nervous system. This is the first body system to be affected in chemical and electrical sensitivities. Work with electromagnetically hypersensitive patients led me to the investigation of endogenous body frequencies and to the development of therapies involving the stimulation of patient specific frequencies by applied electromagnetic fields or potentised water.

3. Nervous and Endocrine Systems

There is cooperation between the nervous and endocrine systems in the integration of the higher body functions. The nervous system is designed to transmit bio-information directly to and from restricted regions of the body through nerve fibres. The central nervous system, composed of the brain and spinal cord, is well established in vertebrates and has specialised cells (neurons) connected with other neurons and receptor or effector cells. In the higher organisms, the close and complementary relationship between the nervous and endocrine systems form the control networks of the neuroendocrine system [4] which make a higher regulatory performance possible.

There are neuroendocrine system effects following on from electromagnetic field exposure [5]. Originally, neurons seem to have been both excitatory and secretory in nature, but the majority of neurons have developed their excitatory role. They can generate electric spikes as a result of an excitation and very rapidly transmit a signal through nerve fibres to other cells. Thus, the nervous and endocrine systems may not always be independent of each other. Hormonal information can be transformed into neural information, and neural spikes can generate chemical signals. Furthermore, hormones may modify the excitability of neurons, while in turn the secretion of hormones

may sometimes be controlled by neural inputs to endocrine organs. The activity of the nervous and endocrine systems may be modified by genetic information and by the internal and external environment.

The pancreas, is both an endocrine gland in respect of the production of insulin but also an exocrine gland in respect of its production of pancreatic juice, has parasympathetic innervation and increased parasympathetic activity increases the secretion of pancreatic enzymes.

4. The A.N.S. and Electromagnetic Hypersensitivity

4.1. Clinical Evidence

On re-examining the case notes of electromagnetically hypersensitive patients I found that half of the most commonly reported symptoms could be attributed to inappropriate responses by the diencephalon and endocrine integrated autonomic nervous system (A.N.S.). The A.N.S. related effects were selected from data obtained by the provocation and neutralization of the symptoms of 200 patients tested in England during the period 1984-1992 with frequencies ranging from 1.8 Hz to 4.2 GHz. These included the following A.N.S. systems: eye and visual, heart, blood vessels, respiration, stomach, intestine, sweat glands, saliva, muscle, thermo-regulation, syncope, yawning, sleep/wake, emotional state.

The results of tests on 120 patients included a total of 661 frequencies between 1.8 Hz and 300 Hz each corresponding to the onset of symptoms that could be regarded as being under the control of the hypothalamus-mediated autonomic nervous system. The Kolmogorov-Smirnov statistical test showed that this data was not randomly distributed. The frequency bands containing 2 Hz and 50 Hz had significantly higher counts than those containing the other frequencies. The symptoms at these two frequencies were consistent with the stimulation of the hypothalamus-mediated autonomic nervous system. Furthermore, the counts at the 25 Hz subharmonic and the higher harmonics of 50 Hz (the UK power supply frequency) were significantly above average. No single symptom predominated at either frequency. The symptoms most frequent at 2 Hz involved: thermal regulation, eyes, heart, respiration. At 50 Hz they were predominantly musculo-skeletal, involving pain and involuntary movements.

Challenging patients living in the USA at their 60 Hz power supply frequency gives a higher score than challenging them at the 50 Hz of Europe's power supplies [6]. This may be an example of an acquired sensitivity. The 2 Hz reactions were common to patients on both sides of the Atlantic and may represent a fundamental resonance in the autonomic nervous system.

A set of data was obtained within a two week period during a visit to the Environmental Health Center, Dallas, in November 1992. Then, 55 patients were seen and tested under environmentally controlled and consistent conditions. The results for their neutralizing frequencies showed a remarkable spread of frequencies, ranging from brain-wave frequencies, to microwave frequencies. Three significant peaks showed up on 'Monte-Carlo Simulation' (Dr. R.D. Baker, personal communication), these were at 0.7-0.8 Hz ($p < 0.0001$), 7-8 Hz ($p = 0.0002$) and 800-1000 MHz ($p < 0.0001$). It is well documented that 7.8 Hz stimulates the hippocampus and several commercial stimulating devices use this frequency.

Of these 55 patients, 32 had abnormal body fields when checked before testing commenced. The results showed three well-defined peaks: 0.6-1.0 Hz ($p = 0.0045$), 4.4 Hz ($p = 0.0019$), 6.2 Hz ($p = 0.0004$). The peak, 0.6-1.0 Hz, is in the band of EEG delta waves. The peaks at 4.4 Hz and 6.2 Hz span the band of EEG theta waves. These frequency bands were found to be useful for stimulating a normal body field in electrically depressed patients. They were also effective in giving relief from pain in the limb stump of amputees. Surprisingly they restored the "normal" body field into the region of space where the leg would have been before amputation. No effects on body fields were found for frequencies within the alpha wave band (8-13 Hz).

This work with electromagnetically hypersensitive patients [7] led the writer to the investigation of endogenous body frequencies and the development of therapies involving the stimulation of patient specific frequencies by applied electromagnetic fields or potentised water and, because of the extreme sensitivity of some patients has led to the development of frequency measurement techniques based on radiesthesia.

Quboa [8] developed an a.c. electric field strength and magnetic flux density meter for environmental measurements. The (f.s.d.) measuring range was 0.1 - 1000 V/m and 100 nT - 100 μ T in steps of 5 Hz from 10 - 95 Hz, 50 Hz from 100 - 950 Hz, 500 Hz from 1000 - 19000 Hz. This was applied to the measurement of the homes and work-places of electrically hypersensitive patients and the field and frequency distributions of electrical apparatus such as fluorescent lighting, televisions and computers, to determine the fields that could trigger reactions in these patients. Attempts to measure any fields and frequencies in the vicinity of reacting patients with this apparatus were not successful. From clinical case records, it is clear that certain patients have emitted significant radiation when reacting, enough to be incompatible with electronic apparatus.

The autonomic nervous system is part of a control network involving the cerebral cortex, the diencephalon and the endocrine system. There are electrical pathways, there is the secretion of a chemical substance in response to an electrical stimulus, and there are interaction sites at which the absorption of a chemical substance gives rise to electrical signals. In tests involving electromagnetically hypersensitive patients, the environmental electromagnetic fields appear to be affecting a feedback loop comprising: cerebral cortex

- autonomic nervous system - hypothalamus - cerebral cortex. Such a neural pathway is consistent with the rapid responses (within seconds of challenging) which these patients show. Direct patient testing does not detect slow responses which may involve the endocrine system and occur hours or days later. In such cases the surrogate method must be used for investigations.

4.2. Theoretical Implications

The A.N.S. integrated neuro-endocrine system gives a biological system the advantages of the rapidity of a neural network with the stabilisation provided by a chemical feedback path. If the phase shift around any feedback loop reaches 360° when the gain exceeds unity, then self-sustaining oscillations result at the frequency for which this condition applies. The provision of a single very long time-constant is one way of preventing the occurrence of a 360° phase shift. This the endocrine system provides.

Very high electrical amplification is needed to trigger a nerve impulse from a single electronic charge or photo-event. This may amount to a gain of 10^9 to 10^{10} . It is very difficult to prevent $1:10^{-9}$ to 10^{-10} parts of electrical feedback being present, enough to give unity gain around the loop. That is all that is necessary for instabilities and oscillations to occur at whatever frequency gives a 360° phase shift. With the chemical feedback of the endocrine system, reverse reactions determined by chemical pathways limit unwanted feedback. The rate of unwanted chemical reaction pathways is either the reverse reaction rate of an enzyme reaction or the rate of spontaneous bond breaking under thermal agitation which is negligible for stable compounds.

What is needed from the clinical and environmental point of view, is a battery of tests to assess dysfunction in specific parts of the autonomic nervous system following electromagnetic or chemical challenge.

5. Chemical Effects and EM Hypersensitivity

5.1. Free Radicals

McLauchlan [9] has produced evidence to support a theory of how electromagnetic fields may cause physical damage to biological systems. Weak magnetic fields may affect cells by allowing free radicals to survive in the body in larger numbers and thereby damage the DNA.

In chemical reactions, bonds break and then re-form. Most of these bonds consist of pairs of electrons with opposite spins. When a reaction occurs, the bond breaks and then both partners 'reclaim' their electron from the bond and search for a new partner. Free radicals

are these 'ex-partners', which have become free-roving agents. In order to reform a bond, two radicals that meet must have electrons with opposite spins (a 'singlet pair'). Often, 'same-spin' radicals meet each other, with the result that no coupling occurs, and the pair quickly separate to search for an 'opposite-spin' radical with which to form a singlet pair.

Unsuccessful pairings are more likely than successful ones because, there is only one way that an opposite-spin singlet pair can form but, three ways in which like-spin electrons can unite. Triplet pairs, when exposed to a very low static magnetic field, easily break and reform into a singlet pair. But, as the field is increased, two of the three triplet states become decoupled from the singlet state completely. This stops two-thirds of the radical pairs from reacting and could occur in a magnetic field as low as 8 mT. The magnetic field does not affect the nature of the product, only the amount of it formed.

5.2. Oxidative Stress

In the present environment, the body's oxidative defence mechanisms are placed under stress due to environmental pollutants and nutritional deficiencies [10]. Of importance in this context are the essential dietary constituents, the anti-oxidant vitamins, A, C and E, together with selenium, an essential component of the per-oxylolytic antioxidant, glutathione peroxidase.

Evolution has not provided for the increased antioxidant protection required to counter the oxidative stresses placed upon the human body by the modern environment. Atmospheric pollutants, such as oxides of nitrogen, sulphur dioxide and ozone, and carbon-based pollutants such as polycyclic hydrocarbons, all compromise the natural oxidative defences of the cell, as do solvents, alcohol and even the polyunsaturated fatty esters in modern diet. Electromagnetic fields can increase oxidative stress by increasing free radical concentrations and this extra oxidative stress occurs in an already stressed cell. It provides the ideal conditions for damage to the DNA.

To simulate realistically the effects of electromagnetic fields, it is essential either to carry out experiments under conditions of oxidative stress or under conditions of antioxidant depletion. The electromagnetically hypersensitive patients already have a body load which includes a wide range of chemical stressors when their electromagnetically triggered symptoms appear.

5.3 Nuclear Magnetic Resonance

Nuclear magnetic resonance is a phenomena associated with atomic nuclei having an odd number of either protons or neutrons. The observation of NMR effects depends upon having a system which can detect a net absorption of energy by a small excess population of nuclei. Because of this, technological applications use very strong magnetic fields and high frequencies. but, biological systems do not have this limitation [11]. The nuclear

magnetic resonance frequency is proportional to the magnetic field strength and the Larmor precession frequency. In the case of the proton, this frequency is about 2 kHz in a typical geomagnetic field. NMR effects for protons, and other nuclei, have been observed in measurements of biological cell dielectrophoresis, dielectric constant and loss measurements of biological materials; in mean-generation-time, cell size and population measurements for cells cultured under NMR conditions. Microwave induced (posterior, subcapsular) cataracts on *in vitro* bovine eye lenses are produced at very low microwave power densities when the microwaves are modulated at a frequency which satisfies proton NMR conditions. The results of satisfying proton NMR conditions during the growth of bacterial cells were unexpected and spectacular. They resulted in the same total cell mass but, with almost twice as many cells of half the size [12]. Magnetic resonance conditions may also affect singlet to triplet transitions.

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2.2. Cellular Stress

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WATER AND BIO-COMMUNICATION

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ABSTRACT

A wide range of biological cells show general oscillatory phenomena and a wide range of biomolecular systems are sensitive to weak environmental electromagnetic fields particularly in the low frequency region or to radiofrequency fields modulated by low frequencies. Human circadian rhythms and temporal morphology imply a high degree of coherence. Frequency information can be 'imprinted' into water and metals and on to a light beam but, deuterium oxide would not 'imprint'. This implies that both the protons and electrons in water must be co-operatively coherent. The frequency information in 'imprinted' water can propagate through aqueous and metallic systems which thus become channels for bio-communication.

1. Water as a Memory

Frequency information can be 'imprinted' into water and metals and on to a light beam [1-3]. It does not imprint into deuterium oxide which means that both the protons and the electrons in water must be co-operatively coherent. The frequency information in 'imprinted' water will propagate through aqueous and metallic systems. 'Imprinted' water can carry long-range electromagnetic bio-information, including such chemical information as may be present at a large distance from a molecule. It cannot mimic the short-range chemical bonding interactions that characterise a chemical reaction. It is only at short-range that a molecule can distinguish whether it is receiving information from 'imprinted' water, electromagnetic radiation or another molecule.

2. Water and the Coherence of Biological Frequencies

The cell division cycle of the typical adult human cell takes 18-24 hours, the higher plants have a 10-30 hour cycle, embryonic cells and bacteria may have cycles between 25-70 minutes. There are techniques for synchronizing cell division to facilitate experimentation. The triggering events that initiate DNA synthesis are not known, they may be electrical [4]. What is clear is that there are "windows" [5] during the biological cycle in which the system is particularly sensitive to its electrical environment and especially to any frequencies present during certain cell activities.

Alternating magnetic fields can affect the lac operon system of *E. coli* [6]. This involves going to the DNA to get the instructions for the synthesis of beta-galactosidase. The core of DNA is high in protons, so any local disturbance such as the deposition of energy selectively into DNA protons might be expected to lead to a measurable cell division rate change.

Oscillatory chemical reactions can occur if the reaction rate is limited by the concentration and the diffusion of a reaction component. External magnetic fields can affect concentrations through singlet-to-triplet transitions [7], electromagnetic radiation might be similarly effective through cooperative interactions with strongly excited polar molecular states [8].

Any oscillator must have a process involving positive feedback, i.e. a stimulatory signal from the output reaching the input. In the absence of external stimulation. Positive feedback will give amplification which may result in oscillations triggered by the noise inherent in any system [9]. Weak external signals can synchronise an oscillator, whereas stronger signals will saturate the system. In general, if a coherent oscillation is involved, then a sine wave is the appropriate synchronizing stimulus, if magnetic flux quanta are involved, then a square or pulse-train waveform is appropriate.

A wide range of biological cells show general oscillatory phenomena [10]. The first (1983) direct detection of radiofrequency emissions from yeast cells [11] has now been mostly replicated [12]. Ross Adey [5] has presented evidence of the sensitivity of a wide range of biomolecular systems to weak environmental electromagnetic fields either in the low frequency region or, with radiofrequency fields modulated by low frequencies. Breithaupt [4] has considered the bio-information transfer properties of biological rhythms and their function in temporal morphology. Wever [13] carried out a 25-year program of research into human circadian rhythms which imply a high degree of coherence. This involved persons living for prolonged periods in underground dwellings shielded from environmental fields. Unexpectedly, the deep body temperature and the sleep-wake cycles had a remarkable sensitivity to weak 10 Hz fields which were able to entrain free-running body rhythms and even force a 23-hour daily cycle.

It was known to the ancient Chinese that the acupuncture meridians in the human body have regular periods of activity (Yin), and passivity (Yang) over the 24-hour period. The effects of the solar and lunar tides and environmental low-frequency fields on circadian rhythms have been summarized by Smith and Best [1]. Plants respond electrically to the variations in the geomagnetic field which precede day-break at ground level, or to an artificial field having the same rate of change [1]. Dubrov [14] has described a very wide range of effects of the geomagnetic fields on biological rhythms and circadian rhythms. Semm, Schneide and Vollrath [15] broadened their investigations of the pineal involvement in circadian rhythms and its reactions to light and darkness, to consider the

effects of magnetic field changes comparable to the strength of the geomagnetic field (0.5 G, 50 μ T). Reiter [16] has written extensively on the pineal, and on melatonin as the chemical expression of darkness. Power supply fields (which are highly coherent) have also been found to affect the melatonin rhythm [17] and the writer has detected resonances at both 50 Hz and 60 Hz in a sample of pineal extract, which in turn suggests that the worst possible frequencies were chosen for the world's power supply systems since, melatonin is also an anti-cancer agent.

3. Electromagnetic Fields in Biological Systems

In general, routine clinical equipment for measuring the electrical signals from the body (ECG, EEG, EMG), is restricted in its frequency coverage and analysis capabilities. The heart-beat is a prime example of a highly coherent oscillation in a living system and small variations in the periodicity have been used diagnostically by Rein and co-workers [18, 19]. Living systems have cyclical patterns of frequency variation over a wide range of frequencies and these can be altered by external electromagnetic fields at levels typical of those in the environment.

When biologists get round to using the magnetic vector potential from a toroidal coil instead of the magnetic field of a Helmholtz coil to investigate a living system they may find the results surprising. Dr. Mae-Wan Ho writes, "The results with the toroidal coil are quite tantalizing. Despite the fact that the magnetic field is negligible, significant increases in abnormalities (in *Drosophila* embryos) are found over matched controls, and both when the embryos are in place before or after the power supply is switched on" [22].

4. Frequencies in Biological Systems

4.1. A Coherence Frequency Measurement Technique

The frequencies of resonances in water, potencies and biological systems can be measured using the the experimenter's autonomic nervous system as a highly sensitive detector. The sample needs to be excited with an alternating field (magnetic or magnetic vector potential) from a solenoid or toroid. The sample, which might be a tube containing potentised water, and the toroid need to be aligned on a North-South axis with an accuracy of $\pm 45^\circ$ at fields well above the threshold of detection, although a tolerance of $\pm 5^\circ$ is needed close to the threshold for detection. This orientation may be required to avoid interference from the vector potential of the geo-magnetic field which is in the East-West direction and which seems to be the reference vector for biological coherence effects.

For the writer to be able to detect a 1 kHz resonance in water, a magnetic vector potential $A > 17$ nWb/m (calculated rms value) is required at the sample. The detection threshold increases linearly with distance from the toroid between 0.3 m and at least 4 m [2].

The hands and arms of the experimenter are also on the North-South axis, and should be one on each side of the sample to be measured. This leaves one hand free to tune the oscillator feeding the toroid or solenoid. The other hand can hold a pendulum which gives a clear indication when a resonance is reached by amplifying the increased natural muscle tremor. The resonant frequency of the pendulum should match the natural (2 Hz) resonance in the autonomic nervous system. The fields in a resonant specimen produce an left-to-right unbalance in the experimenter [2]. The (left-handed) writer gets a counterclockwise rotation of the pendulum at resonance when facing West. A water resonance giving this rotation corresponds clinically to a therapeutic frequency while, that giving the opposite rotation produces stressful reactions.

If the experimenter changes from facing West to facing East, the sense of all the responses is reversed. Most substances and potencies show alternate counter-clockwise and clockwise rotations at successive resonances, beginning at the lowest resonance frequency and ending at the highest with a counter-clockwise rotations.

The objective detection of resonances in water has been achieved and repeated on rare occasions using a technique whereby a pair of gold wire electrodes is dipped into a cuvette containing the sample of potentiated water, these are connected to a suitable low-noise, high-gain, narrow-band amplifier. Similar results have been obtained at Wekroma AG, Switzerland, using a Fourier Transform Spectrometer with signal averaging over a large number of measurements [2]. The frequencies measured in this way were the same as those originally imprinted into the water and the same as measured on the sample by the above subjective method.

The problem of repeatability may be that of finding out how to couple an electrode to self-trapped radiation without destroying it.

4.2. Results of Frequency Measurements

Each successive dilution and succussion adds one more stimulatory and one more depressive resonance to those found in the previous potency [23]. For all the materials and biological systems so far measured the harmonics were not the usual octave apart but, were spaced according to a high-order power-law for which the only reasonable model is a fractal equation.

There are some exceptions to the above:

- (i) Water held and potentiated by a healer contained a sequence of only therapeutic frequencies, starting at the heart frequency and becoming a continuum at high frequencies.
- (ii) Dilutions of hydrogen peroxide contained only therapeutic frequencies which, if succussed became a continuum. With hydrogen peroxide, there was no potentiation if diluted with air-free water.
- (iii) Dilutions of formaldehyde contained only stressful frequencies which, if succussed became a continuum.
- (iv) Deuterium oxide would not potentiate when succussed in an alternating magnetic field or magnetic vector potential until diluted with water $> 5\%$, $< 10\%$ (by volume).
- (v) Electrotherapy apparatus can potentiate water at any frequencies within its pass-band. Whether these are therapeutic, or stressful, depends upon the amplifier parameters selected.

If a sample of 'imprinted' water is placed on the left of the toroid and a sample of 'clean' water is placed equidistant to the right and succussed, the latter acquires a phase-inverted 'imprint' of the water on the left. A practical application for this is for allergy therapy since it provides a way of converting stressful frequency components of allergens into therapeutic ones beyond the bandwidth of electrotherapy apparatus.

It is also possible to detect proton NMR in a water sample (2.13 kHz in a 50 μ T geomagnetic field) and to confirm that it is and NMR, this resonance can be tuned through by moving a small magnet in the vicinity of the water.

It is also possible to use this method to detect resonances in series or parallel resonant inductance-capacitance (LC) circuits. The LC circuits do give octave spaced harmonics with the fundamental and all the other odd harmonics giving a stimulatory (counterclockwise) pendulum rotation, while all the even harmonics give a depressive (clockwise rotation).

4.3. Erasing Water Memory

We now know much more about how to erase the 'water memory' albeit as the result of trying to measure erased samples. Heating water above 70°C will erase its memory, as will passing an amplifier off-set current greater than about a microamp through the water sample, or even the tube being handled by the 'wrong' person. But, most importantly, placing the water in a hypomagnetic container (e.g. a closed mu-metal box) erases not only water 'memory', but also tablets and liquid preparations of homoeopathic potencies and is very useful for producing "controls" by erasing a specimen after it has been measured. The threshold steady magnetic field necessary for the maintenance of water 'memory' in the environment is about 400 nT. At this field, the mean separation between

magnetic flux quanta (2.07×10^{-15} Wb) would be $71 \mu\text{m}$. A strong magnetic field $>250 \mu\text{T}$ will suppress 'water memory', although in this case the original imprint is recoverable by succussion.

4.4 Coherence Frequencies in Living Systems

Work with a single cell system became possible during a visit to the laboratory of Dr. F-A Popp, (Technology Centre, Kaiserslautern, Germany) [24]. Here measurements were made at low frequencies and radio-frequencies on a single (10 cm long) filamentary cell of *Acetabularia*. The frequencies were observed to jump discontinuously by a small amount at reasonably regular intervals of a few minutes; the pattern repeated after about 25 minutes provided that the oscillator was only switched on while measurements were actually being made. When the oscillator was left on and tracked continuously on a 'stimulatory frequency', the periodicity dropped to about 2 minutes. While the oscillator was left on a 'depressing frequency' between measurements, no frequency jumping took place at all, even over several hours so long as the oscillator was left on that frequency.

This frequency jumping phenomenon applies equally to the human subject. Again, a depressing frequency stops all frequency jumping, while tracking the stimulating frequency speeds the frequency jumping from about a 2 hour cycle to a 6 minute cycle. Acupuncture points relate to specific body organs or systems. Electroacupuncture apparatus can be used to measure the frequencies on a meridian by first imprinting them into water in the output beaker, which can then be measured.

The empirical rule evolved for the therapy of electromagnetic hypersensitivity is to use an oscillator set to the highest stimulatory frequency or, to 'imprint' some, or all, of the stimulating frequencies into water or other substance tolerated by the patient. Thus, it seems that the therapy involves stimulating lethargic autonomic systems in the patient. The persistent presence of a depressing frequency in the environment can paralyse the natural frequency jumping of a living system, with most uncomfortable results.

5. Coherence or Wüst Waves

Specimens of potentised water seem to be well protected by wrapping the glass container in aluminium foil. The reason for this probably lies in the small critical angle (3.5°) for coherence waves passing from aluminium into water. It is theoretically possible to make lenses to focus coherence or Wüst waves. The critical angles do not alter measurably from at least 1 Hz to 100 kHz. Neither did there seem to be any appreciable dispersion when the velocities of coherence waves were measured by Fizeau's method [3], or in the case of stationary coherence waves on Lecher's wires. Therefore, coherence wave dispersion spectroscopy may not be available although, interference methods of spectroscopy remain a possibility. The 'imprint' of potentised water can be picked up by a light beam shone

through it and this can be transferred into water or metal on which the beam falls by succussing it.

If an insulated wire is arranged to conduct a coherence wave as described previously [2] and is then passed through a hypomagnetic enclosure, it is found that is a critical magnetic field $>740 \text{ nT}$ within the enclosure for propagation beyond it. At this field, the mean separation between magnetic flux quanta would be $52 \mu\text{m}$. A coherence wave will propagate through a 10A fuse wire (calculated diam. $322 \mu\text{m}$), It will not propagate through a 3A fuse wire (calculated diam. $140 \mu\text{m}$), there is what is probably a 1-D coherence in a 5A fuse wire (calculated diam. $200 \mu\text{m}$), Coherence waves can be conducted through water in tube diameters $>2.5 \text{ mm}$ but, not in tubes $<2 \text{ mm}$ diameter. These dimensions are all of the same order of magnitude.

The brass beakers that are used to contain samples whose signals are to be introduced into electroacupuncture apparatus provide a convenient alternative method of coupling a coherence wave into a wire. They are usually provided with more than one socket so that a pair of wires can be lead away, each carrying an identical coherence signal. If a beaker contains a sample of water excited at its imprinted frequency by a toroid, and if such a pair of wires is passed one either side of the end of an air-cored solenoid resting on end (e.g. 3000 turns/m, 50 mm diam.) through which a small steady current can be passed, this provides the basic arrangement for the Aharonov and Bohm experiment. It does give changes in the pendulum rotation sense proportional to the current in the solenoid for when the water in the beaker is excited at either the ESR or proton-NMR frequency in the ambient magnetic field.

The same result is also obtained if the water is contained in a circular plastic tube placed around the solenoid. This is in effect replacing the metal wires and the beaker containing the water sample with a water channel. The simultaneous application of both ESR and proton-NMR frequencies to water produces a phase inversion of the response.

The same changes are obtained for a metal sample (copper) placed in the beaker, but in this case only at the ESR frequency. The NMR for both Cu_{63} and Cu_{65} were detected, but, varying the current in the solenoid produced no effect at these resonances. Likewise, there was no effect at the NMR frequency of deuterium when an ampoule of pure D_2O was placed in the beaker. It has not been possible to try hydrogen and deuterium absorbed in palladium. This implies an absence of coherence wave phenomena for ions heavier than hydrogen, which just manages to be a quantum particle. Also, the 'imprint' in a metal must involve only electron coherence. The metal ions are already spatially coherent.

6. Potentiation by Contact

As already mentioned, water 'memory' can be imprinted with a frequency using an alternating magnetic field, or with an alternating magnetic vector potential plus either succussion or a magnetic field. However, the information will also slowly imprint by contact. For example, if a glass tube containing 'erased' water is placed in a beaker of water imprinted with a range of frequencies, the frequencies will slowly become imprinted, the higher frequencies imprint more quickly than the lower frequencies. This suggests that imprinting does not need energy other than thermal excitation, and that the imprinting awaits the random arrival of the correct frequency component in the thermal noise to provide a necessary bifurcation. The random statistic theoretical curve is close to the water-water curve. This is based on the uncertainty relations for the number of randomly arriving quanta within the coherence time which are sufficient to give an energy equal to thermal energy (kT) [11]. Chlorided-silver wire has no potential barrier with water at low frequencies and imprints the frequencies in times given by assuming the equivalent statistics for coherent quanta. The frequency imprinting times for copper and gold immersed in water come between these two limits. As Fröhlich often remarked, onset time delay is a hall-mark of coherence.

7. Discussion

The possibility of coherence in the ground state and the availability of the Josephson effect is supported by QED theory applied to water. For potentiation and coherence wave propagation in water, a cluster of domains 1 - 2 mm in size (for a metal about 200 μm) is needed to have enough weak-link junctions to provide memory capability. If these coherent domains behave as superconducting regions, then magnetic flux will not penetrate them. The ambient magnetic flux provides a mechanism to prevent domain coalescence. If this falls below 740 nT (average magnetic flux line separation 52 μm) water memory is erased; this is the likely result of domain coalescence dissipating charge patterns giving rise to Josephson voltages between domains. In magnetic fields $>250 \mu\text{T}$, the flux may force the weak-link junctions too far apart for memory read-out. There is no dissipation of the charges, since memory is recoverable on succussion. Writing to memory with a frequency becomes a process of setting up internal charge patterns which give Josephson voltages between domains corresponding to the applied frequency. Read-out would be through the AC Josephson effect when a small supercurrent crosses a weak-link junction. In the *in vivo* state, redox reactions which work with electron-pairs, are the obvious source of read-out supercurrents. The process of succussion is then seen as redistributing the coherence domains and their separating lines of magnetic flux. The diluent will only have noise in memory. The addition of a diluent to a potency/mother tincture is the addition of a larger memory capacity, realised on succussion, thereby permitting greater resolution and thus higher coherence. The signals in memory should increase in proportion to the number of potentizations, the noise from the diluent as their square-root.

8. Conclusion

In these lectures I have tried to present a picture of what can be found out about coherence in water and living systems by simple experimental techniques, many of which have had to be devised to meet circumstances as the results unfolded. The detailed mechanisms leading to electromagnetic hypersensitivity are still not determined, but it is clear that the patients are really sick. Those results obtained by subjective measurements obviously need repetition by objective physical techniques as soon as these can be designed and I trust that I have provided some useful design parameters. I can only plead that the good general first surveys the battle-field on foot.

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