

Structure and Memory in Water

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Abstract.

Attention is drawn to a recent article, which appeared in the International Journal of Quantum Chemistry, discussing the amount of largely unrecognised structure present in water. This theoretical article supports and amplifies experimental work published by Benveniste in the journal *Nature* in 1988. The possible consequences for a solid scientific foundation for homeopathy are immediately obvious, although a great deal more work is necessary in order to be able to present a totally watertight justification for homeopathic remedies.

Introduction.

People have speculated for some time over whether substances, such as water, actually have a memory. However, it was in 1988 that a truly staggering article appeared in the journal *Nature* purporting to report the experimental observation of this property assumed by many to be merely an attribute of animals, particularly humans. The article in question [1] by a team, headed by Dr. Jacques Benveniste, claimed to have observed that extremely dilute biological agents were still capable of triggering relevant biological systems. In fact, they even claimed this to be so in the absence of actual physical molecules of the agents concerned. Some of the experiments had been reproduced in laboratories other than Benveniste's and members of these laboratories co-signed the article. However, as has been noted in a popular book on homeopathy [2], this article "provoked a flurry of comment and resulted in the rerun of the experiments under the 'scientific' eyes of a fraud detector, a journalist and a magician." Presumably, by 'a journalist', the writer of this book meant the editor of *Nature*, but the person concerned was by training a physicist and might have been expected to have had some elementary knowledge of information theory and that it had been applied to physical systems. Although a relatively old subject in its own right at that time, information theory had been coming into physics via such books as that of Brillouin [3]. It might have been thought by some that this fact would have introduced a more cautious note into some of the condemnation of Benveniste's work.

The article itself appeared in the issue of the journal for 30th June 1988 and the ensuing furore was such that the then editor of *Nature* summed up his reading of the situation and called a halt to further correspondence in the issue of 27th October 1988, after allowing Dr. Benveniste a chance to answer his critics. What really caused the furore? The answer is best summed up by the 'Editorial Reservation' which appeared with the original article. This said that "readers of this article may share the incredulity of the many referees who have commented on several versions of it during the past several months. The essence of the result is that an aqueous solution of an antibody retains its ability to evoke a biological response even when diluted to such an extent that there is negligible chance of there being a single molecule in any sample. There is no physical basis for such an activity." In the later commentary, attention was drawn to the fact that one of the concerns of the editor of *Nature* was that the publication of the paper was "certain to excite the interest of the homeopathic community". Given this, therefore, it is surprising the article ever appeared in print, but appear it did even though it was stated there was no physical basis to explain the claimed phenomena.

It is this final statement which is now called into question with the appearance of an article purporting to give the biophysical basis of the Benveniste experiments [4] and it is the purpose of this note to draw attention to this work which could be of vital importance in helping establish the scientific validity of homeopathic remedies within the medical fraternity as a whole.

Theoretical background.

The basis of information theory is now well-established. Following the approach of Brillouin [3], if P denotes the number of states in a system, then the information memory capacity (denoted by I) in 'bits' is defined to be

$$I = \ln P,$$

where, if a problem is considered with N different independent selections, each corresponding to a binary choice (0 or 1), the total number of possibilities is

$$P = 2^N$$

and so, the information is

$$I = N \ln 2.$$

Alternatively, the entropy function of statistical thermodynamics is given by

$$S = k \ln P,$$

where k is Boltzmann's constant.

It follows that, for the above expression for P ,

$$S = k \ln(2^N) = kN \ln 2.$$

Further, it may be noted that the first and second laws of thermodynamics may be combined into the equation

$$dU = TdS + d'W,$$

where dU denotes the internal energy, T the absolute temperature and $d'W$ the work done on or by the system. In terms of memory capacity, this becomes

$$dU = kNT \ln 2 + d'W$$

and it is seen immediately that the energy required to add one bit of memory to the system is given by

$$kNT \ln 2 = \frac{\partial U}{\partial N}$$

where the partial derivative is evaluated with the work term held constant.

It might be noted that heat capacity is necessarily a positive quantity [5] and, therefore, this last equation leads to the realisation [4] that a program written using ΔN bits of system memory dissipates energy of at least $[kNT \ln 2] \Delta N$. As noted previously, this constitutes an irreversible bound on a classical computation imposed by the second law of thermodynamics.

This brief introduction to some of the basic ideas of information theory and the link with statistical thermodynamics provides one part of the basis for the promotion of the idea that water possesses memory. The second part derives from a detailed study of some of the properties of water itself.

Properties of water.

Water is such a commonly available and apparently straightforward liquid that most take for granted and the popular picture, derived from standard chemistry, of it being composed of an oxygen atom attached to two hydrogen atoms belies a quite detailed, complex structure. Standard textbook chemistry has an enviable history of genuine scientific success but it is actually confined by a simple scheme of charges interacting via static Coulomb forces; that is, it is totally reliant on electrostatics and omits all mention of electrodynamics and the consequent radiation field. It is this basic neglect which is responsible for the inability to recognise phenomena which are, in fact, dependent on that radiation field. This is doubly unfortunate since physicists and engineers are only too aware of this cause and effect since it is due to this dynamical effect that so many modern-day appliances work; for example, the electric light on which we all depend and the wifi connections which are assuming increasing importance in our lives. It has been speculated that a goodish percentage of effects in condensed matter physics make use of the radiation field in one way or another but it still doesn't seem to have found a place in much of basic chemistry.

This new paper [4 and references cited there] draws attention to the fact that water has been shown to contain electric dipole ordered domains due to a condensation of photons interacting with molecular dipole moments. These ordered domains yield an unusually high heat of vaporisation of water per molecule and this has been shown to imply a high degree of memory storage capacity. In a similar manner, it has been shown that the partial entropy per molecule of an ionic species dissolved in an aqueous electrolyte implies a large number of bits of information per ion. This number is, in fact, so high as to lead to the expectation of

such ions being attached to an ordered water domain. This state of affairs allows for semi-permeable membranes which may either permit or forbid the passage of an ion through a small gap. This would be expected to depend in part on the state of order in the ion attachment. Such a situation, based on information or, equivalently, entropy, indicates a program for biological cells analogous to polymer DNA based programs. It is ion flows through membranes in nerve cells which allow human memory storage in nerve cell networks in the human brain. These possess roughly the same magnitude for biological information capacity density and it well surpasses the comparable figure for commercial computer memory devices.

It should be noted also that the magnetic properties of water are again of great interest. In fact, a coherent ordered domain in water shows almost perfect diamagnetism, although the total diamagnetism in water is weak. This follows due to the magnetic flux tubes being capable of permeating normal water regions just as they can permeate type two superconductors via their normal regions. Trapped magnetic flux tubes may also carry information and give some directionality to what would otherwise be isotropic pure water.

The domains in water also exhibit a rotating electric dipole moment. If an electric field is applied, strings of electric dipole aligned water domains are formed and many such strings form a dipolar field bundle of strings. If the field is applied by employing a voltage between two electrodes then the bundle will start at one electrode and continue to the other. These strings will have an effect on the entropy and, therefore, on the information capacity of the water memory. Further, according to the two fluid model of water structure, an ion could flow with virtually no friction through the bundle of strings from one electrode to the other.

Finally, it should be noted that, if the bundles of these strings are orthogonal to an applied magnetic field, ionic transport resonance effects can occur between the time varying part of the magnetic field and the cyclotron frequency associated with the uniform part of that field.

Conclusions and consequences.

It follows that the ordering of water through coherent domains yields sufficient structure for truly significant memory capacity. This view receives support from statistical thermodynamics and information theory. It is seen that ordered water domain polarized string bundles affect ionic motion and this can act as switches in networks of nerve cells. Many of these actions should be measurable by employing magnetic resonance imaging techniques.

However, what are the consequences for homeopathy in all this? In homeopathic remedies, the concentrations of various substances are reduced dramatically, to the extent that most practicing chemists would claim it impossible to find any residual effect. What is forgotten in the assessment is the possibility of dynamic effects having a part to play and this is well illustrated by the case of a magnetic recording tape. In the investigation [4] being reviewed here, it was found that, using electromagnetic theory, the existence of electromagnetic domains in water was confirmed. These are actually small ferro-electric structures within which electric fields are trapped. Hence, water is ferro-electric and it is this which is fundamentally responsible for many intriguing properties of water, including its memory.

It has to be recognised that creating a firm scientific basis for homeopathy which would satisfy the critics and sceptics would be a huge task involving a detailed literature search before laying down new theoretical foundations. However, it does seem that the work discussed here offers a good starting point and, if so, a research project based on the published writings of such as Benveniste and Widom could eventually benefit homeopathy itself as well as a great many individual people.

References.

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