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HOMEOPATHY: A FRONTIER IN MEDICAL SCIENCE
EXPERIMENTAL STUDIES AND THEORETICAL FOUNDATIONS

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TEXT without figures

Chapter 7

7. THE BIOPHYSICAL PARADIGM

The search for a scientific rationale on which to base a hypothesis regarding the mechanism of action of homeopathy led to examination of the subject of complexity, within the framework of which, essentially, the rational explanation of the "law of similars" and of the possible effects of very small doses of natural compounds and extracts deriving from pathological processes has been inserted. We have already stressed that this is the inspiring concept of homeopathy and makes it relatively easy for homeopathic drugs to play a complementary role in the context of scientifically orthodox pharmacology.

We must now continue further along these lines and address the problem of ultra-low doses (more precisely termed *high dilutions*, or *high potencies* according to classic homeopathic parlance), i.e. those which contain virtually no molecules of the active compound. There can be no doubt that the conceptual leap here is enormous and that the topic we are about to address appears so much out of this world as to make any attempt to suggest that such issues can be investigated scientifically seem no more than mere folly. In the face of such challenging objections, which critics of ours have raised on numerous occasions, since we have no incontrovertible proof (we have seen that the clinical trials and biological tests have yet to yield definitive evidence, and many apparently outstanding results need to be repeated and reproduced), we have no alternative here but to refer to what more authoritative figures than ourselves have had to say apropos of studies in the frontier areas of science.

We are all familiar with the position of the philosopher of science, Karl Popper, one of the best known and most widely accepted modern epistemologists, according to whom scientific method does not consist in demonstrating and affirming certainties, but rather in the continual invalidation of previous theories. In other words, it is a matter of "learning systematically from errors," in the first place by having the courage to commit them, i.e. by propounding new and even daring theories, which one then attempts to confute by means of experiments [Popper, 1969].

A similar concept had already been voiced by Claude Bernard, who might be defined the father of the experimental method in medicine: "Those who have condemned the use of hypotheses and preconceived ideas in the experimental method have made the mistake of mixing up the process of designing the

experiment and the ascertainment of the results. It is perfectly true to say that you have to ascertain the results of an experiment with the mind unbiased by hypotheses and preconceived ideas, but absolutely nothing must prevent you from making hypotheses when setting up an experiment and searching for means of information. On the contrary, as we shall see below, imagination must be given free rein; ideas are the source of all reasoning and all invention; it is to ideas that all forms of initiative are due. The imagination should not be suffocated or crushed under the pretext that it may be harmful: it only needs to be controlled and given a decisive cast of truth, and this is something quite different. (...) Even if the hypothesis is not confirmed and has to be abandoned, the facts that it has helped to unearth will remain an integral part of the indestructable body of scientific knowledge" [Bernard, 1973, pp. 33-34].

Later, Bernard goes on to say: "When, in our science, we construct a theory, the only thing we can be certain of is that, by and large, this theory is false in terms of absolute value. Theories are only partial and provisional truths which are used in order to proceed with the research, as we use the landings of a staircase to rest on the way up; they correspond to the present state of our knowledge and therefore are necessarily bound to change with the progress of science, and this process will be all the more rapid, the more backward science itself is in a given field. On the other hand, as we have said, our ideas arise from the study of previously observed facts which are interpreted at some later stage. Now, countless causes of error may creep into our observations, and, despite all our attention and perspicacity, we can never claim to have detected them all because often we do not possess the means, or the means are still far from perfect. Our reasoning, then, if it is to guide us in experimental science, does not oblige us to accept all its consequences. Our mind remains free at all times to accept them or to question them. One should not reject an idea, when it comes into being, simply because it is not consistent with the tenets of some prevailing doctrine. One should rather heed one's feelings and give free rein to one's imagination, on condition that all our ideas only serve as a pretext for other experiments that may provide us with new and fruitful data" [Bernard, 1973, p. 46].

Those who propose to tackle subjects such as the ones we intend to deal with here, at least in terms of ideas and hypotheses, are therefore not operating beyond the pale of the scientific method. Of course, what we report here constitutes a body of facts and theories which still need to be properly systematized, but can certainly offer scope for experimental tests which will eventually confirm or disprove various specific points.

The need to go beyond chemistry and biochemistry, thus entering into the domain of a *biophysical paradigm*, to explain the effects of very high homeopathic dilutions is obvious: if we do not wish to accept *a priori* (as we do not wish to here) either the "null" hypothesis (= it's all an elaborate swindle) or explanations of an extra-scientific type (the action of certain, undefinable "entities" or "energies"), once the lack of molecules beyond the 24x or 12c dilutions has been ascertained mathematically, we are obliged to think in terms of information related to phenomena of a physical nature, such as vibrations of electromagnetic fields or particular spatial structures of the solvent which in some way reproduce the "image" or "information" of the original solute.

In addition to theoretical considerations, the participation of physical mechanisms in the action of high dilutions of homeopathic remedies can also be deduced from the results of several experiments already reported in Chapter 4, demonstrating that:

a) The dilution-dynamization phase is critical and is influenced by the nature of the solvent and by the atmospheric environment in which it takes place.

b) The activity of high dilutions can be destroyed by heat and by electromagnetic waves.

c) The specificity of the effect (biological tropism) also exists in the absence of the original substance.

Though it is premature to draw general laws of action of homeopathic remedies from such indications, all these considerations prompt us to focus our attention on the physicochemical characteristics of the solutions used and on the role played by electromagnetic phenomena in the structuring of liquids and in biological communication.

The possible application of electromagnetism in medicine was envisaged, albeit with a great deal of caution, by Hahnemann himself, who, in paragraph 286 of the *Organon*, stated: "The dynamic force of mineral magnets, electricity and Galvanism act no less powerfully upon our life principle and they are not less homoeopathic than the properly so-called medicines which neutralize disease by taking them through the mouth, or by rubbing them on the skin or by olfaction. There may be diseases, especially diseases of sensibility and irritability, abnormal sensations, and involuntary muscular movements which may be cured by those means. But the more certain way of applying the last two as well as that of the so-called electro-magnetic machine lies still very much in the dark to make homoeopathic use of them. So far both electricity and Galvanism have been used only for palliation to the great damage of the sick. The positive, pure action

of both upon the healthy human body have until the present time been but little tested." These comments highlight once again, on the one hand, Hahnemann's perspicacity and insight as a forerunner of modern developments in medicine, and, on the other, the ingrained characteristics of the medical researcher and experimenter.

In summary, to be able to accept that the ultra-diluted homeopathic drug acts via a biophysical mechanism, two basic questions need to be answered:

a) Can a solvent, such as water or water containing various percentages of ethanol, incorporate and maintain some form of order or organization acting as a vehicle for information in the absence of the original solute? In other words: does the notorious "memory of water" exist and, if so, how can it be accounted for?

b) Admitting that order and information can be incorporated and maintained in the highly diluted solutions, how can they interact with biological phenomena? In other words: how does the body interpret and receive these properties of the homeopathic remedy and use them in a regulatory sense?

It must be perfectly clear to all and sundry that it is only by providing convincing answers to these questions that any serious claim can be made for the existence of a scientific basis for high-dilution homeopathy.

7.1. The biophysics of water

In this chapter we shall present many indications, reported in the literature, regarding the peculiar properties of water, which may be of interest with a view to providing an answer to the first of the two above-mentioned queries. In this case, too, of course, we will not be able to develop the topic in systematic, specialistic terms, which would be a task beyond our personal expertise and outside the scope of this book. The study of water is one of the major chapters in physics [Franks, 1982; Franks and Mathias, 1982]. Despite the fact that the knowledge of this extraordinary substance is far from complete, what is known for sure at present *does not rule out* the possibility, at least, that water may act as a store and transmitter of biologically significant information.

7.1.1. Certain characteristics of water

As we have already pointed out, water, despite the simplicity of the molecule, exhibits a typical complex behavior in phase transitions and in the liquid state, when it finds itself in an "*open*" system which exchanges energy with the environment (Chapter 5, Section 8.1). The topic is analyzed here in greater detail, providing notions of a theoretical type and indications of an experimental nature.

Interpretations of the behavior of water in the liquid state are generally formulated in terms of short-range interactions, such as, for instance, the hydrogen bonds and the van der Waals forces, which in some way link together the water molecules in a kind of *network*. Since the hydrogen-oxygen bonds are polar covalent bonds, with the hydrogen positive compared to the oxygen, the attraction between the negative region linked to the oxygen atom and the positive region associated with the hydrogen atom of another molecule leads to a combination of various water molecules, with the result that an irregular network of interlinked tetrahedral forms is created (see Figure 26) [Stillinger, 1980]. Moreover, the water molecule is not linear, but the oxygen atom forms an angle of 104.5° with the two hydrogens. As a consequence, the molecule has a resultant *dipole* moment.

Figure 26. A: hydrogen bond between water molecules; **B:** tetrahedral and irregular polygonal structures in liquid water.

In three dimensions the interlinked tetrahedral structure forms very regular pentagonal and hexagonal figures in ice, though such as to be present also in the liquid, except that they continually vary in a chaotic manner in the latter. Statistically, a network structure with a certain form changes to a different form every 10^{-11} or 10^{-12} seconds. The changes can come about as a result of the fact that the molecule is sufficiently elastic to support minor distortions of the aperture angle.

Each water molecule is capable of forming four hydrogen bonds with the neighboring molecules, in each of which a proton (H^+) is directed towards the electrically negative zone of the oxygen atom. One molecule behaves as a donor of protons to another two, whereas it also becomes an acceptor of protons from another two: the protons are therefore shared by two oxygen atoms and consequently are in continual *movement* or *oscillation* between two atoms.

These types of interactions have been described as "hooks" which link up the neighboring water molecules and constrain them, when the temperature is below 100 °C, in a more condensed (fluid) physical state compared to water vapor where there are no bonds, but only random collisions between molecules.

The liquid must be defined as a homogeneous yet irregular arrangement of molecules. The structure of the liquid is not crystalline as occurs in the case of a solid, and research has also ruled out the possibility that there may be crystalline areas in the liquid [Finney, 1982], though certain investigators talk about a "quasi-crystalline" structure [Stillinger, 1980]. In fact, to say that the arrangement of the molecules is irregular does not mean that the water molecules are in a state of total disorder; the disorder is limited by the particular geometry of the molecules, which tend to form bonds in the form of tetrahedra, and probably by other phenomena related to the dipole moment which will be considered here below.

No anywhere near precise description of the laws governing the arrangement of water molecules and thus of the phase changes of water has yet been produced. Here, for instance, is what the physicist D. Ruelle has to say about it: "Here we have a tricky problem for theoretical physicists: demonstrating that, if we increase or decrease the temperature of the water, there will be phase changes that yield vapor or ice. A tricky problem, alright... but too difficult! We are still a very long way from providing the demonstration required. Effectively speaking, there is not a single type of atom or molecule for which it can be demonstrated that crystallization will occur at low temperatures. These problems are too difficult for us. In actual fact, it is by no means rare in physics to find oneself faced with problems that are too difficult to solve..." [Ruelle, 1992, p. 136].

There are two major unsolved problems: the first has to do with the interaction between neighboring molecules. In the model presented above (chaotically interlinked tetrahedra) we need to assume that the total energy of N molecules depends on the sum of the energies of interaction between each individual pair of molecules, i.e. of each hydrogen bond. Given two molecules that interact in a liquid, it must be assumed that the binding energy is not altered by other neighboring molecules. This assumption would not appear to be applicable to water on the basis of both theoretical and experimental considerations [Finney, 1982]. The existence of influences of other neighboring molecules on the binding of two molecules is certainly not devoid of consequences: multiple cascade interactions are generated which may substantially change the random behavior of the molecules, introducing phenomena of *cooperativity* and *coherence*.

A second major point has to do with what happens when a different molecule is dissolved or immersed in water: the structure will certainly change and break, according to the properties of the new molecule. In addition, at the interface between macromolecules and solvent, an enormous structural reorganization of the water takes place, the latter taking on thoroughly new configurations, even at a considerable distance from the solute molecule. In this case, the cooperative effects are undoubtedly very important. In this connection, various investigators talk about "*vicinal water*" by which they mean water which is near to solid surfaces or macromolecules and is influenced by these. For instance, a protein chain with alternating positive (NH) and negative (CO) chemical groups should polarize the surrounding water, reduce the rotation and translation movements and give rise to the formation of many orderly states of water molecules. These particular modifications of the structure of water extend, according to the various investigators, over distances measuring from 5 to 200 molecular diameters from the surface considered.

This phenomenon does not coincide with the well-known molecular interactions between water and surfaces (e.g. ion-dipole or dipole-dipole interactions), which are of the high-energy, short-range type. Vicinal water, on the other hand, extends much further than the specific surface interactions [Drost-Hansen, 1982]. This may have major implications in the functioning of cells, which are known to be rich in macromolecules, fibers and membranes.

The properties of vicinal water are peculiar: it is denser than normal water and freezes only at temperatures many degrees below zero, and its solvent properties are also altered. It has been suggested that many enzymes, thought to be dissolved in the cytoplasm, are actually weakly associated with the surfaces of fibers or membranes by interaction with vicinal water, with the result that many metabolic processes are thought to occur in conditions of organization on two-dimensional planes rather than in the chaotic motion of free water [Clegg, 1982].

For the purposes of illustrating the possible implications that acceptance of the existence and importance of "vicinal water" would have in the cell, we can refer to the theory expounded and developed primarily by Ling and coworkers [Ling *et al.*, 1973; Ling and Ochsenfeld, 1983; Rowlands, 1988]. Sodium ions are known to have a low concentration within the cell as compared to outside it, whereas the opposite is true of potassium ions. The current theory is that these differences in concentration are maintained by membrane pumps, but, according to Ling, if this were true, there would be an excessive energy consumption just to operate the pumps. Ling thus suggests the hypothesis that the potassium inside the cell is almost entirely bound to proteins, whereas the sodium ions, which have a greater hydration volume, are less soluble in the orderly, polarized vicinal water of the intercellular fluids, compared to the ordinary water present in the extracellular fluids. Thus potassium is thought to be retained and sodium excluded from the cell by means of mechanisms which do not require a constant supply of energy.

The possible implications of vicinal water for cell physiology have also been discussed and documented by Bistolfi within the framework of a biophysical theory of biological communications systems [Bistolfi *et al.*, 1985; Bistolfi, 1989]. Following in the footsteps of Hameroff [Hameroff, 1988], Bistolfi postulates that the water adjacent to the cytoskeleton is highly ordered, i.e. aligned with polar bonds on the surface of the filamentous proteins. This ordered water may be coupled with the coherent dynamics of the proteins (which, as is known, are made by the assembly of a large number of subunits), opposing the thermal dissipation of the protein oscillation energy. In other words, the filamentous proteins may be conductors of vibrational signals and the vicinal water may be a kind of insulating agent favoring conduction.

Recently, evidence has been accumulating in favor of the hypothesis that water molecules participate in proton transfer in various biochemical reactions, including, among others, the photoreceptors [Khorana, 1993]. A series of concatenated water molecules joined together by hydrogen bonds are thought to form a system whereby protons (H^+) "hop" from one oxygen atom to another and travel significant distances. In other words, the water molecules arranged in order are thought to resemble a lead carrying a current of positive charges.

7.1.2. Superradiance

After outlining some of the unsolved problems in the study of the properties of water in the liquid phase, we can now tackle certain issues with a closer bearing on homeopathy. These relate to theoretical models and empirical experience which suggest the existence of a real physical basis for the homeopathic phenomenon.

A group of physicists from the Milan Institute of Nuclear Physics (Emilio Del Giudice, Giuliano Preparata, and coworkers) have for some years now been working on the formulation of a descriptive model of the physics of dense matter and in particular of water in the liquid state, which may make a by no means negligible contribution towards solving the enigma of homeopathic phenomena, or, at least, may serve as support for those who regard some form of biological activity of ultra-diluted solutions as "theoretically not impossible."

We shall attempt here to summarize the essential aspects of the work of this group [Del Giudice *et al.*, 1988a; Del Giudice *et al.*, 1988b; Del Giudice, 1990], ignoring many the technical details and mathematical formulae to be found in the above-cited studies.

These investigators take as their starting point a critique of the theory of water in the liquid state which contemplates only interaction via the hydrogen bond between one molecule and another. According to their calculations, when the water vapor liquefies, the gas-liquid phase change, which involves something like 10^{23} molecules/liter, is too swift and massive (also bearing in mind that it takes place at 100 °C, under very strong thermal agitation counteracting the electrostatic attraction) to be explained solely by a model based on the existence of the hydrogen bond uniting two neighboring molecules. A more satisfactory model should also include another ingredient, which is lacking in the previous models, namely the *electromagnetic radiation field*, i.e. a long-range messenger which brings order to the vibratory motion of the molecules.

It has been seen that water molecules are electric dipoles. The contribution of this small electromagnetic field to the dynamics of water is negligible in quantitative terms if the interaction between molecules is taken as the sum of intermolecular binary interactions. When, however, a large number of elements (molecules) interact via the electromagnetic field, beyond a certain density whose value depends on the wavelength of the electromagnetic field, the system sets itself in a configuration in which most of the molecules *move coherently, being kept in phase by the field itself*. This phenomenon is termed *superradiance* and consists

practically in an oscillation of a large number of water molecules (an estimated 10^{15}) in unison over time in a certain space (corresponding to half the wavelength). Given that the typical wavelength of electromagnetic radiation is 200 μm, the coherence domain would extend approximately 100 μm.

The studies of the Milan group have now gone far beyond the discovery of superradiance, in that another two issues of basic importance for the problem of high-dilution homeopathy are dealt with in their model:

a) The stability of such a phenomenon over time (something similar to a "memory").

b) The interaction between the superradiance regimen and the solute molecules.

According to quantum theory, it is possible that two separate phases coexist in liquid water: one phase subject to the coherence regimen, and another made of molecules that move randomly like a gas, which is a situation also described for superfluid helium and in keeping with experimental observations whereby the hydrogen bonds between the water molecules are much fewer than would be theoretically possible if all the molecules were involved [citations in Del Giudice, 1990]. That proportion of the molecules that vibrate coherently "see" one another as immobile and thus the electrostatic attraction due mainly to the hydrogen bonds is not random as in the gas, but sequentially ordered in packets in which the forces of attraction are enormously greater than in the gaseous phase.

Del Giudice and Preparata's theory is that the groups of molecules that move coherently are maintained in the superradiance regimen both as a result of the actual electromagnetic field produced (which, as we have seen, controls significant distances) and because they are protected by the "shell" of strong hydrogen bonds formed as described. The coherent phase of the water is therefore rather stable and other molecules find it hard to enter. According to Del Giudice, within the coherent phase the entropy is virtually zero, and the thermal and solvation properties of water depend only on the fluid (gas-like) phase.

What we have to ask ourselves now is how such a model can be the basis for the storage of some type of information. This would be possible if the coherent electromagnetic vibration could be influenced, or *modulated*, by outside chemical or physical forces, so as to take on a certain frequency and somehow enter into communication with other chemical, physical or biological systems. This hypothetical property of water is supported by the model according to which it resembles a *free electric dipole laser*. In this type of laser, an ondulatory field induces, in a beam of free electrons, an oscillating electric dipole, transverse to their movement, which is coupled to the electromagnetic radiation, vibrating coherently with the latter [Del Giudice *et al.*, 1988a]. Starting from the finding that water molecules possess a considerable dipole moment, these investigators have provided the theoretical demonstration that they *can interact coherently* with a suitable form of electromagnetic radiation. Given the phenomenon of collective interaction, it is not necessary to postulate a very strong electric field, since even the slight electric perturbation around a macromolecule with a dipole moment, or the field present on the surface of a colloidal aggregate would be enough. Around such "impurities" present in the water, then, a macroscopic domain could be generated, of the order of a few hundred μm, formed by the superradiance of water. Since distances of this order might involve tens or hundreds of cells in a body tissue, the potential importance of such a phenomenon on the biological organization will be immediately appreciated.

To get back to the subject of homeopathy, according to Del Giudice the particular preparation of the homeopathic drug enables us to postulate that the succussion accompanying the dilution produces a regime of turbulence such that for a moment or so the shell of hydrogen bonds of the coherence domains *relaxes*, thus offering an external electric field (such as that generated by the dissolved material) a chance to communicate with the polarization field of the water and assign it its new vibratory frequencies. At the end of the succussion, the shell will re-form, protecting the new frequencies from outside disturbances.

According to this model, the presence of other molecules dissolved in the water (as impurities, mineral salts, or biological molecules) causes no problems for the frequencies thus stabilized, both because the solute is in the fluctuating phase and does not interact with the coherent phase, and because the frequencies of the molecules in solution are much greater than those of the semi-solid dispersion grains and macromolecules with which homeopathic drugs are normally prepared (see trituration process) [Del Giudice, 1990].

It may seem advisable at this point to recall that, given the present state of our knowledge, the theories set forth above still await convincing experimental confirmation demonstrating, for instance, by chemical or physical means, the existence of the superradiance domains postulated. However, we feel we should stress that modern quantum physics does not rule out the possibility that water may possess hitherto unknown properties and that these are somehow compatible with the empirical observations of homeopathy. Those who accuse homeopaths of scientific inconsistency should first familiarize themselves with the physics of water in the liquid phase, so as to be in a position to raise objections (whereby certain theories are in

themselves absurd, or certain phenomena impossible) not based merely on so-called "common sense." Judging natural reality on the basis of common sense, or even on the basis of prejudice, has often proved a substantial source of error, and this is all the more true when we enter the various fields of quantum physics.

Though far from clarifying or unequivocally demonstrating the physical basis of homeopathy, physical theories such as the superradiance theory enable us to confute those who, being unaware of the possibilities of water-mediated long-range interactions, consider it theoretically impossible for a molecule to transmit information independently of direct contact with another molecule.

7.1.3. "Activation" of water and colloidal reactions

On dissolving a normal substance, such as an electrolyte or sugar, in water, a system is obtained consisting of molecules or ions dispersed in the aqueous medium, which cannot be separated by filtration and are invisible with optical means, even under the electron microscope. If, however, we suspend a powder of insoluble substances in water, a heterogeneous system is obtained consisting of microscopic solids in a dispersing aqueous phase, such that the various phases are easily separable using filter paper. Somewhere between these two extremes there is a range of sizes of particles suspended in a dispersing medium, such as to make it hard to establish whether it is a homogeneous solution or a heterogeneous suspension. Such systems are called colloids, and the colloidal state must be regarded as a special state of matter, with its own particular properties.

These properties are, for example, the fact that colloids are not retained by common filters; they spread slowly in electrophoretic fields; they can easily pass from the colloidal to the gel state, forming reversible or irreversible clots. In addition, colloids present particular optical properties such as the Tyndall effect (visibility of light rays passing through a colloidal solution) and the absorption in particular bands of the visible spectrum depending not only upon their chemical composition but also upon their physical state (particle size, surface charge, variations according to pH). Colloidal systems consist of particles made up of from 10^3 to 10^9 atoms, with sizes ranging from 1 to 100 nm. There are both inorganic (e.g. colloidal gold, colloidal sulphur, silver bromide) and organic colloids (starch, cellulose, agar-agar, natural rubber, polymerized cell proteins).

The formation of colloidal particles (clusters) occurs from atoms and molecules according to the "rules" of aggregation by diffusion, complicated by the fact that even the particles themselves have a tendency to aggregate. As mentioned previously (Chapter 5, Section 7), these physical processes are neither fully ordered nor completely random, being part of those growth phenomena which can be interpreted in terms of the geometry of fractals and chaos [Sander, 1986].

At a level of magnitude smaller than colloids, but still larger than molecules, are the so-called microaggregates. These consist of a group of atoms or molecules which may range from 4-5 to 100-200, and may form a very large number of structures, all stable, though to different extents [Berry, 1990]. In these microaggregates, the forces of attraction and repulsion between the various atoms or molecules make for the best conformation in terms of potential energy, bearing in mind the obvious fact that protons and electrons attract one another, whereas there are repulsive forces within the pairs of protons and electrons. Normally, the proton-electron interactions are important only within the same atom or molecule, but when various atoms or molecules approach one another beyond a *critical point*, the interactions with neighboring elements become very important. Formation of the aggregate is determined when the energy is minimal, but calculation of the permitted energies on the basis of quantum physics shows that the energy of the aggregate is confined to a series of levels, or steps.

Another interesting property of microaggregates is that they go over from the solid to the liquid phase and vice versa on variations in temperature, but, unlike ordinary matter, the melting point and freezing point do not necessarily coincide, with the result that it can easily come about that both solid and liquid phases of a microaggregate suspension may coexist over a broad range of temperatures.

This situation is reminiscent of the properties of colloids and of the aggregates of organic molecules which oscillate between monomeric and filamentous forms, or between sol and gel. This is an example of the *bistability* phenomenon, typical of complex systems (cf. Chapter 5, Section 8.2).

Microaggregates can change configuration not only as a result of variations in temperature, but also as a result of other energies supplied by electromagnetic vibrations (a microaggregate normally vibrates approximately 10^{10} times per second) [Berry, 1990].

Despite the objective difficulty this field of study presents (it cannot be tackled either by using the investigational means of molecular biology, nor by using those of solid-state physics), its importance also in the sphere of medicine is only just beginning to emerge: we know that many reactions of living cells occur at microaggregate level or in the colloidal phase of many proteins, consisting in rapid monomer to polymer transitions and vice versa. The structure and function of the cytoskeleton are determined to a substantial extent by the microtubules, whose most characteristic - and largely mysterious - property is their *dynamic instability* due to their easy dissolution and reassembly.

The editors of the journal *Current Biology* claim that dynamic instability promises to be one of the most interesting biological processes for biochemists and biophysicists in the near future [Pollard and Goldman, 1992]. Extracellular matter also exhibits behavior patterns typical of colloids: we need only think, for example, of blood clotting phenomena or the thixotropy (conversion of gel to sol) of fluids bathing the articular cavities during movement.

We concern ourselves with colloids here because this particular field of chemistry enables us, on the basis of published trials, to illustrate an interesting physico-chemical phenomenon which occurs in water treated according to particular procedures. Essentially what interests us is the fact that the formation of colloids is speeded up very considerably by water treated with electromagnetic waves.

The phenomenon of so-called "*activation*" of water was extensively described by Piccardi (Director of the Institute of Physics of the University of Florence) back in the '30s [Piccardi, 1938; Piccardi and Corsi, 1938; Piccardi and Botti, 1939], but it did not cause quite the stir that perhaps it deserved to cause. The revealing reaction is easily reproducible: solutions of gold chloride, formaldehyde and sodium carbonate are mixed in adequate proportions and heated; in the space of a few minutes the color of the colloidal gold formed (blue-violet) can be observed. With numerous variants, this type of reaction is described in text books of colloidal chemistry, amongst other things because these substances today find practical applications in various fields, including electron microscopy.

Piccardi noted that if the water was treated with various agents causing the formation of electromagnetic radiation phenomena (shaken glass bulbs containing mercury, electric arcs, rods of electrically charged ebanite, for example), the water acquired the ability to bring about the formation of colloidal gold (and also of other colloids) at a faster rate. What most astonished Piccardi was that this property *persisted for months* after the treatment. This prompted him to perform countless check tests, all of which he meticulously described, and eventually, as he himself admitted, he was forced to "bow to the evidence." The fact is hardly any less amazing today, but there is no sign that the phenomenon described by Piccardi has led to any further advances in our knowledge of the structure of water. Probably, the time was not ripe and the discovery was seen more as an oddity or freak phenomenon than as a true scientific breakthrough.

To our knowledge, the investigatory method described by Piccardi was recently adopted also by researchers from a medical institute in Rome (the San Raffaele Institute, under the direction of Professor Emilio Dido). These researchers have obtained the colloidal gold formation using double distilled water after treatment for a few minutes with electromagnetic waves in the radiofrequency range, while untreated water was much less active in promoting the reaction. This served to set up a system capable of indicate pathophysiological alterations of the organism when distilled water, treated in coils excited by a high-tension generator pulsed at radiofrequency, is introduced as a perturbing factor into an electric circuit involving the patient (F. Borghini, personal communication). This latter topic will be treated more extensively below (Chapter 7, Section 3.2).

A series of trials, with results in keeping with those reported here above, have been described by Markov and coworkers [Markov *et al.*, 1975]. These investigators described a "magnetization" phenomenon in water exposed to a static magnetic field of 450-3500 G for periods of 30 to 120 minutes. The water thus treated is reported to show marked alterations (persisting intact for at least 24 h) of the Raman spectrum and of electrical conductivity, and also a greater degree of germination-stimulating activity of various seeds.

The results reported above serve essentially to support the hypothesis that water possesses particular properties which have yet to receive due consideration and which are evidentiated by its ability to catalyze colloidal reactions. Since these properties are acquired not by the addition of particular substances, but by means of physical treatment, we must deduce that water is endowed with various physical states which are chemically significant, i.e. they act as vehicles for information or energy utilizable by chemical systems. As these physical states are maintained for significantly lengthy time periods, we can by and large speak about a "memory" of water, even though this kind of test tells us little about the type of specificity or selectivity this phenomenon may present. The colloidal gold formation reaction appears to be influenced by a series of

possible different treatments of water, and therefore cannot depend on any precise form of electromagnetic radiation. In a certain sense, then, it is a broad-spectrum reaction which is not very specific, but which may, perhaps precisely for this reason, be of great importance all the same for laying the foundations for a properly documented controlled study of the physicochemical properties of water. In the not too distant future we may perhaps find other systems, possibly nearer to the biological colloids, which are more sensitive or more selective for this type of study.

A series of studies by Benveniste's group are significant in this context. These researchers have used the experimental model of the isolated and perfused guinea-pig heart (see Chapter 4, Section 2) to test the transfer of molecular signals via an electronic circuit [Aïssa *et al.*, 1993; Benveniste *et al.*, 1994b]. Closed ampoules of histamine, ovalbumin or LPS, and water (as controls) were placed inside a coil through which an electric current was passed. An amplifier then delivered the current to another coil in which was inserted a closed ampoule of water. The water treated with the current from the coils with histamine, ovalbumin and LPS and perfused through the guinea-pig heart was capable of increasing coronary flow. The water treated with the current from the coil containing water, on the other hand, had only a minimal effect. The differences were highly significant ($P < 0.001$). A similar phenomenon, consisting in the *"frequency-operated transfer of drugs"* (TFF) had been previously described by M. Citro, who reported achieving pharmacological effects on cells and animals and even in man, using water exposed to electromagnetic frequencies "modulated" by substances of various types (therapeutic effects in the case of drugs, toxic effects on cell cultures in the case of toxic agents such as atrazine, and inhibition of the metamorphosis of frogs in the case of thyroxine) [Citro, 1992; Citro *et al.*, 1993; Citro *et al.*, 1994].

Another approach to the study of activated water has been developed by G. Arcieri [Arcieri, 1988]. Confining ourselves to essential notes and referring the reader to the cited literature for details, the author maintains that water can be "enriched" with electromagnetic frequencies by means of treatment with physical energies (lasers) or with chemical substances, including samples of biological materials such as the blood of healthy and diseased subjects. The demonstrations of the physicochemical changes induced by these treatments were obtained both with nuclear magnetic resonance spectrometry and with Doppler flow-metry (according to Arcieri, this latter procedure serves to highlight physiological changes induced by activated water).

7.1.4. Water clathrates, isotopicity and similar models

According to some investigators [Smith, 1988; Anagnostatos *et al.*, 1991; Anagnostatos, 1994], the "memory of water" is based on the formation of aggregates of water molecules in the form of *clathrates*. What is meant by clathrates, from the Latin *"clathrus"* (= lattice or grating), are hollow formations which the water molecules are thought to assume with a grid-like arrangement, set around an internal niche or cavity. The possibility of the formation of cavities in liquids is universally accepted. In water, the molecules can align themselves in pentagonal or hexagonal forms thanks to their hydrogen bonds; in turn, in certain conditions (agitation or sonication of the liquid) various polygonal conformations can form complex, internally hollow geometrical figures.

On forming the cavities, the surface tension produces a negative pressure inside, which, in the smallest form, takes the form of a dodecahedron (12 pentagons bound together in a geometrically ordered manner), but which may also include nonplanar hexagons. In addition, varieties of chemical bonds other than hydrogen bonds may be involved, such as dipoles between hydrogen and hydroxyl ions [Smith, 1990].

A certain number of molecules of the original compound are thought to be surrounded, once dissolved in water, by a greater number of water molecules which form a kind of shell or niche. Such a niche might possess stability even if the original compound is expelled from the niche itself. Thus, with continual dilutions and succussions, empty clathrates would begin to form inside, which in turn may become the nucleus for the formation of other clathrates, all with the same original pattern [Anagnostatos, 1994].

A considerable variability of forms and combinations would thus be possible in the formation of such micro-cavities. The dodecahedral forms should be capable of binding together in forms similar to helicoidal chains joined by their pentagonal faces. These chains may represent the site of coherent interaction between water and the magnetic field of a current which might cause synchronized "hopping" from one proton (hydrogen atom) to another linking adjacent oxygen atoms [Smith, 1990; Smith, 1994].

Thanks to the ordered, sequential arrangement of the hydrogen bonds, such cavities may be capable of vibrating coherently in resonance with a magnetic field. The frequency of the vibrations would depend upon the shape and length of such structures (in turn dependent upon the original solute), as well as the degree of progressive structuring of the water, as the dilution-dynamization process progresses.

It has been noted [Smith, 1990] that such a model of water makes no provision for the fact that water *emits* radiation or magnetic fields, i.e. that it is an active source of coherence for other systems, but allows only that it may be *a "mirror" of coherence* via weak interactions between external magnetic fields and those generated as a result within the water. This is important, because if there were *emission of energy* by a particular physicochemical structure of water, the latter would be subject to exhaustion in a very short space of time owing to dissipation of energy. If, on the other hand, the interaction occurs as a result of a kind of resonance between a coherence pattern of the solution (caused by the fine structure deriving from the solute) and a frequency pattern of the living organism (deriving from the state, whether normal or pathological, of oscillatory systems), such communication of information by the electromagnetic route does not require the solution itself to emit any radiation or energy.

An analogy could be made with other types of information: a book *contains* information, but does not *emit* it. The information may be fixed on paper for a long time and become significant, in the sense of being able to organize the reader's thoughts, only when it starts to be "in tune" with the reader's receptor and cognitive systems (and here is where the concept of tone, vibration and frequency comes into the picture).

The clathrate model is interesting in that it helps to explain how "aggregates" of water molecules can become the means of transmitting information. It has to be admitted, however, that there is no physical basis to explain the *permanence* of such aggregates in definite forms for sufficiently lengthy periods.

Another interesting theory providing a framework for an explanation of the homeopathic high dilution effects has been proposed by Berezin [Berezin, 1990; Berezin, 1991; Berezin, 1994], based on the physical phenomenon of isotopic diversity (*isotopicity*), i.e. on the well-known fact that most chemical elements are mixtures of several stable isotopes (atoms having a fixed number of protons but a different number of neutrons in their nuclei). Water, for example, is formed mainly by hydrogen (H) and ^{16}oxygen (oxygen isotope ^{16}O), but a small proportion of the molecules are formed by the isotopes deuterium (D) or ^{17}O, or ^{18}O. All these isotopes are stable in solution over time, are present in substantial amounts (^{18}O represents 0.2% of oxygen molecules) and are assumed to be randomly distributed in normal water.

In brief, the essence of the hypothesis is that the distribution of isotopes in water can generate an "*information-carrying pattern*," due to different possible positional organizations of the different molecules. These patterns, which have been named "isotopic lattice ghosts" [Berezin, 1991], may form when the presence of certain molecules in solution causes some specific readjustment in the positional distribution of isotopes in the vicinity. During the preparation of dilutions according to the homeopathic methodology the "seed" molecules would operate as "symmetry-breaking agents" in a system which is put far from equilibrium by the energy provided by succussion. Symmetry breaking in a physical system results in a decrease in its entropy and is equivalent to the generation of information within this system.

Any theory regarding the homeopathic phenomena should indicate some mechanism whereby the coded information is protected from thermal disordering and is multiplied in serial dilutions in the absence of the original molecule. According to the Berezin's theory, the isotopic configurations could be preserved by *polarization effects*, which energetically stabilize the interactions between the various isotopes. The transmission of the pattern from one configuration to other randomly distributed water molecules should be possible because the imposition of a weak perturbation on a highly degenerate system (i.e. having a variety of possible configurations with the same total energy) often "dictates" the choice of a pattern at which the system eventually arrives, a phenomenon similar to the influence of trace substances on the process of crystallization under specific conditions [Berezin, 1994].

As stated for the above-mentioned clathrate theory, in the case of the isotopicity theory, too, it can be said that even if the suggested model is self-consistent, it still provides no guarantee that it describes actual physical reality. The author of the hypothesis recognizes the need for experimental demonstrations, but at the same time maintains that "the very fact of the existence of an *operational model* for the alleged effect might be a stimulating factor for more focused experimental studies" [Berezin, 1994, p. 138].

7.1.5. NMR, infra-red and Raman-laser spectroscopy

The foregoing sections, devoted to superradiance and clathrates, basically have to do with theories which, however, have yet to be confirmed experimentally. The experiments on the activation of water bear witness to the permanence of particular properties capable of catalyzing colloidal chemical reactions. These experiments, however, like the more biologically oriented experiments in Chapter 4, do not enable us to gain insights into the intimate physical mechanism whereby such properties may be justified. In other words, the answer to the question whether homeopathic remedies possess special physical properties remains very much in the dark.

A tentative approach to solving this problem in terms of experimental physics has been adopted by various investigators by means of analysis of *spectra* (bands of absorption, emission or resonance of electromagnetic waves at different frequencies or intensities) obtained with the Raman-laser, infra-red absorbance (I.R.) and, above all, the nuclear magnetic resonance (NMR) techniques on homeopathic preparations.

NMR is known today mainly for its applications in diagnostic imaging, but it has been used above all to study atoms and molecules, in that it allows nvestigation of the behavior of the atomic nucleus when subjected to a magnetic field. Since the nucleus has a dipole moment, the dipole may enter into resonance with sufficiently strong electromagnetic waves, and each type of atom has its own particular resonance frequency. Thus, the NMR spectrum (i.e. the graph plotting the resonance peaks) is directly related to the components of the sample measured and the "geometry" of the molecules. In addition to the spectrum, other parameters considered are resonance relaxation times (T1 = longitudinal relaxation time; T2 = transverse relaxation time). Relaxation is a complex parameter resulting from the dipolar magnetic interaction between intra- and intermolecular vicinal protons, from the molecular rotation and translation movements, from the exchange of protons and the presence, if any, of paramagnetic substances (certain metals, molecular oxygen, free radicals).

The very first studies in this field were those conducted by Smith and Boericke [Smith and Boericke, 1966; Smith and Boericke, 1968], which showed that the structure of the solvent (ethanol and water) as it appears in the region of the OH and H_2O signals in the NMR spectrum, is modified in serial dilutions. The modification is more marked, if succussion is also performed as compared to dilution alone and, even more remarkably, does not diminish, but rather increases with increasing dilution.

Later, other researchers [Young, 1975; Sachs, 1983; Lasne *et al.*, 1989] were to make similar observations, which were then taken up by Weingartner [Weingartner, 1990; Weingartner, 1992], who clearly demonstrated that the difference between an NMR spectrum of a solvent in which sulphur (Sulphur 23x) has been diluted and a spectrum of the solvent alone relates to the intensity of the H_2O and OH signals, whereas that of the CH_2 and CH_3 signals does not vary (the chemical formula of ethanol is CH_3CH_2OH). In particular, the peaks of a homeopathic dilution of sulphur are significantly lower (probability > 99.9%) and broader compared to the peaks for the solvent alone. Weingartner also reports that this difference is not observed for the Sulphur 13x dilution, in the sense that at this dilution the spectrum cannot be distinguished from that of the solvent. He suggests that the lowering of the peaks observed at NMR is indicative of an accelerated proton exchange. This finding may lend itself to many interpretations, but it would appear to be in keeping with the tendency to attribute an important role to the hydrogen bond in the nonrandom association of water molecules.

It should be pointed out that hydrogen bonds play a key role not only in the structuring of liquid and solid water, but also in a number of biochemical and biological reactions where information and energy transfer occur. For instance, it is well known that protein secondary structures (alpha-helixes and beta-sheets) are formed by hydrogen bonds between amino acids and that DNA and RNA structures are maintained by intranucleotide hydrogen bonds. Moreover, it has been shown that ligand-receptor interactions may involve proton donation by the receptor and proton acceptance by the ligand [Fay *et al.*, 1993] within the binding pocket, and that the transmission of the light signal into the rhodopsin molecule involves conduction of protons via "chains" of water molecules interlinked by hydrogen bonds (see Section 7.1.1. above) [Khorana, 1993].

Variations in NMR resonance characteristics, and in particular in the relaxation times T1 and T2, in highly diluted solutions of silica have recently been measured by another research team in France and published in an official journal of physics [Demangeat *et al.*, 1992]. In brief, it was observed that solutions of silica/lactose, prepared in centesimal dilutions according to homeopathic methodology, presented an increase in T1 and in the T1/T2 ratio as compared to distilled water or to diluted and dynamized solutions of NaCl. These changes were also detectable with silica concentrations of the order of 10^{-17} moles/liter. This

experiment is also important because a stimulatory effect of high dilutions of silica had previously been demonstrated on mouse peritoneal macrophages [Davenas *et al.*, 1987; see also Chapter 4, Section 1]. This was therefore the first case in which a difference of a physical nature was rigorously demonstrated between the solvent and the high dilution of a homeopathic remedy whose biological activity was established experimentally.

It would also appear that I.R. spectrophotometric analysis enables us to detect physicochemical changes in high dilutions of homeopathic drugs. Heinz's team [data reported by Barros and Pasteur, 1984] appear to have demonstrated the importance of succussion or dynamization in the preparation method by means of the I.R. procedure. In fact:

a) Substances diluted and dynamized to 30x present absorption bands on the I.R. spectrum.

b) These bands are not presented by solutions which are diluted to 30x but not dynamized.

c) A 30x dynamized dilution loses its property of producing absorption bands at I.R. spectroscopy if subjected to boiling.

d) The absorption bands decrease alternately and unevenly: maximum activity corresponds to the 6, 9, 12, 14, 18, 21, 28 and 30 decimal dilutions, and minimum activity to the 7, 10, 13 and 16 decimal dilutions.

Another method which was used for the study of physical changes in homeopathic dilutions is analysis of the Raman laser spectrum. When a laser beam illuminates a substance, a small proportion of the light rays is diffused with a different wavelength to that of the original light. On examining the emission peaks of these diffusion rays (Raman effect) information is obtained about the physical state (viscosity, molecular distortions, dielectric constant) of the liquid analyzed. It has been reported that homeopathic dilutions of various plants (e.g. *Aesculus*, *Bryonia*, and *Rosmarinus*) produced in 70% ethanol modify the Raman-laser spectrum of ethanol, in the sense that they cause a significant lowering of the spectrum peaks at various frequencies [Luu, 1976]. This lowering of the peaks has been observed in the dilutions from 1c to 7c (and in this case is attributed to a mass action, due therefore to the molecules dissolved), but also in the dilutions from 11c to 30c (maximum dilution tested). In the case of high dilutions, the lowering of the intensity of the Raman-laser effect has been attributed to an electrostatic rearrangement of the molecular environment [Luu, 1976].

7.2. Biological effects of electromagnetic fields

There is still no exhaustive explanation of how a transfer of information from the homeopathic remedy to the body can take place, but, if the problem is couched in physical and not merely in chemical terms, it is very likely that any such explanation must necessarily take account of electromagnetic phenomena in living systems.

The study of the effects of electromagnetic fields in the body has come to take on increasing importance and scientific dignity in recent years, while at the same time that aura of mystery which has favored the exploitation of such phenomena by charlatans has steadily declined. It is true, on the other hand, that even in recent times scientists who devote their attention to the study of electromagnetism in medicine and biology, such as Tsong, for example, are still liable to be accused of dabbling in “magic” [Tsong, 1989]. It is indeed singular that such accusations, sometimes accompanied by negative verdicts regarding the subject's mental faculties, have been levied against many scientists operating as pioneers in this field, including a certain Guglielmo Marconi.

The main reasons for the renewed interest in interactions between electromagnetic fields and living systems consist in three types of factors:

a) Evidence has been building up regarding the efficacy of extremely-low-frequency (ELF) pulsed magnetic fields in therapy, and most notably in orthopedics.

b) From the standpoint of public health, there is a heightened awareness of the risks associated with technological development and thus also with exposure to electromagnetic fields generated, for instance, by high-tension electrical power lines, video terminals, diagnostic equipment, household electrical appliances, and other sources.

c) The topic is being tackled increasingly in experimental terms with studies on cell and molecular models, with the result that a number of possible explanations of the biological effects of low-energy magnetic fields are beginning to emerge.

These matters will be briefly illustrated here below, as a contribution to a better understanding of the emerging biophysical paradigm in medicine and thus of the possible relationship between electromagnetic phenomena and homeopathy. In this case, too, we feel we should stress that our discussion of these issues lays no claim to being in any way systematic, but rather constitutes an attempt to compare in outline and put into perspective many different problems which are otherwise regarded as strictly pertaining to other specialist sectors or as being "alternative" medical practices, inasmuch as they are based on phenomena which are largely unclear from the scientific point of view.

For the purposes of making it easier to understand the basic concepts used in bioelectromagnetism and the experimental evidence reported here below, we will briefly explain the terminology and the measurement units used. A diagram illustrating the various types of electromagnetic waves, together with their wavelengths and frequencies is given in Figure 27.

Figure 27. Electromagnetic radiations of various wavelengths and frequencies.

The frequency of an electromagnetic field is the number of cycles per second of the electromagnetic wave, or the number of pulsations of the field itself per second and is measured in Hertz (Hz). The wavelength (λ) is the distance between two wave peaks and is measured in meters (or in multiples of submultiples of a meter). Obviously, the higher the frequency, the lower will be the wavelength.

Electromagnetic waves are used, as is known in the case of telecommunications, as *information vectors*. For this purpose a *carrier* wave is used with a frequency selected in a very broad range according to the transmission and reception systems. This carrier wave is specifically *modulated* in relation to the information to be conveyed, i.e. its length and height are subtly altered and can be slightly increased or reduced to a variable extent over time (frequency and amplitude modulation, respectively). In this way, a piece of equipment *tuned* to the carrier wave can perceive the modulation and, after decoding it, the information contained in it.

The *intensity* of the electrical field is provided by the electric potential over a given distance and is expressed in volts/meter (V/m) or millivolts/centimeter (mV/cm). When a biological system is exposed to an electrical field, the mobile charges shift in the direction induced by the field itself, thus forming a *current*, which is measured in amps (A) or in submultiples of an amp. With reference to a certain area of tissue or organ traversed by electrical charges, there will be a certain density (J) of the current itself, which is measured in amps/square meter (A/m^2) or in $\mu A/cm^2$.

The electric field and the magnetic field are closely related according to Faraday's law of induction. When a pulsed magnetic field is applied to an electrically conducting material (such as living matter), an electric field is introduced perpendicular to the direction (vector) of the magnetic field. This electric field obviously depends on the surface of the area concerned and is proportional in intensity to the frequency of the magnetic field and its intensity.

The intensity of the magnetic field is measured in Gauss (G) or, to use the more modern SI unit, in tesla (T) or submultiples of a tesla ($1\ T = 10^4$ G). To have two terms of comparison, the intensity of the earth's magnetic field is of the order of 0.02 to 0.07 mT (0.2 to 0.7 G), whereas that used in diagnostics by magnetic resonance is of the order of 0.1 to 10 mT (1 to 100 G) [Walleczek, 1992].

7.2.1. Effects on the body

We intend here to examine low-energy, low-frequency radiation, which acts with very different mechanisms compared to ionizing radiation. The latter causes biological effects through ionization (detachment of electrons from the atomic orbits) of the molecules and thus gross alterations such as damage to chromosomes, peroxidation of lipid membranes, and so on. In contrast, the energy of radiation with frequencies from 0 to a few hundred GHz is too low to cause physicochemical changes of this type and at most is able to yield thermal effects (heating, used, amongst other things, in the functioning of microwave ovens).

The effects of non-ionizing electromagnetic fields on the human body may be both of a pathological type and useful for therapeutic purposes. As regards the damaging effects most commonly studied, we have

to refer essentially to studies which appear to demonstrate an increase in tumors in exposed subjects [Pool, 1990]. The topic is much debated and the epidemiological data have been confirmed only with regard to a number of childhood tumors (leukemias). As regards the uses for therapeutic purposes, the techniques most extensively employed are electromagnetic stimulation of osteogenesis, in cases of pseudoarthrosis and retardation of fracture consolidation [Chiabrera *et al.*, 1984]. This is not the place for a detailed review of the pathological or therapeutic effects of electromagnetic fields, this today being an area of major development, and so we will confine ourselves to outlining the basic molecular and cellular aspects.

There are many natural sources of weak electromagnetic fields: sources outside the body include, for instance, the earth's magnetic field (which is exploited by a number of birds, fish and dolphins for direction-finding), radiation from the stars which emit radiofrequencies, the sun itself (particularly in certain phases of its activity) [Konig, 1989], the waves irradiated by telecommunications and radar systems, and electrical power lines. The sources inside the body are multiple and range from the electrical activity of the nerves and muscles to the electric fields generated by a number of fish and other marine organisms (used for the purposes of recognition in the dark and for defense), to the generation of light by cells such as leukocytes (chemiluminescence).

The electrocardiogram and electroencephalogram are no more than two methods of measuring the endogenous electrical activity of the heart and the nerve centres. Electrical activity is also generated in bone when it is deformed; such activity can be defined as piezoelectric and appears to be important for directing the growth of bone trabeculae along lines of force. In actual fact, one of the first clinical uses of weak magnetic fields was precisely the induction of bone repair [Bassett *et al*., 1974].

Animal organisms have developed very marked sensitivity to electromagnetic waves. Without going beyond the most obvious field, we need only mention the sensitivity of the eye to light, which makes it capable of perceiving only a few photons.

The experiments by Smith and Monro [Smith *et al*., 1985; Monro, 1987; Smith, 1988; Smith, 1989; Smith, 1994] illustrate the concept of "sensitivity" to minimal perturbations of electromagnetic fields. These investigators (Smith works in the Department of Electronic and Electrical Engineering of the University of Salford) have reported a series of experiments performed in collaboration with allergologists from the Lister Hospital in London, in which they succeeded in inducing allergic manifestations in patients with immediate hypersensitivity to many substances, simply by bringing them into close contact with sources of electromagnetic radiation. The allergic manifestations could set in rapidly at particular frequency bands ranging, according to the individual patients, from only a few mHz to a large number of MHz. It was not, then, so much the intensity of output of the oscillator (a few V/m) that was important as the frequency and coherence.

It is not only curious that these investigators demonstrated the ability to trigger allergic attacks with electromagnetic waves, but also that the patients sensitive to this type of stimulation themselves produced electromagnetic signals during the allergy attacks, though the latter were provoked chemically. Such emissions could be documented by interference with the recording of magnetic tapes and even, in some cases, by interference with the functioning of electronic equipment such as computers. According to Smith [Smith, 1988], these are electrophysiological phenomena very similar to those known to us from many species of fish.

It has been demonstrated that a number of species of fish are capable of perceiving and responding to electric fields with intensities as low as 0.000001 V/m [Bullock, 1977], which corresponds to the most marked sensitivities found in allergic subjects. Again according to Smith, such sensitivities may enable the fish to locate food at great distances: it has been seen, in fact, that living cells, such as, for instance, yeasts, emit electromagnetic waves in radiofrequencies at levels of approximately 0.1 V/m [Smith, 1988; Pollock and Pohl, 1988]. The same ability, Smith claims, may have served primitive man in his search for food.

In the studies conducted by Smith and Monro, the authors talk about homeopathy and the memory of water. In the course of the allergometric tests in the sample of hyperreactive patients, the researchers realized that allergic reactions triggered by contact with chemical agents could be neutralized by treating the patients with particular frequencies. If the same frequencies were used to treat mineral water, the latter acquired the neutralizing therapeutic properties. If, on the other hand, the water was exposed to frequencies capable of triggering the attack, it acquired the properties of an allergen.

The treatment of the water was done by inserting glass test tubes containing the water in solenoids or thoroids powered by an oscillator. The changes induced in the water, capable of triggering allergic attacks in hypersensitive patients, persisted for 1-2 months. Incidentally, at this point it is interesting to note that the stability of the homeopathic remedy in aqueous solution is traditionally short-lived, of the order of months,

whereas Hahnemann himself used water-alcohol solutions precisely because they were much more stable and long-lasting (years).

Quite apart from the fact that only a minority of allergic patients exhibited this extreme sensitivity and were suitable for the execution of such tests, the demonstration of the ability of water to incorporate electromagnetic information and transmit it to individuals reactive to it remains of great interest and significance. This series of experiments should therefore be repeated by independent centers and, if confirmed, may constitute a valid argument in favor of the effective presence of metamolecular information in aqueous fluids.

7.2.2. Molecular and cellular effects

It is well known that electromagnetic radiation can cause substantial changes at molecular level, but the bulk of attention, up until not very long ago, was devoted to the effects of medium-to-high energy radiation, such as X-, gamma- and ultraviolet rays. As mentioned above, investigations into the mechanisms of the biological effects of nonionizing radiation have recently begun (see Figure 27).

Most protein molecules are capable of passing reversibly from one conformational state to another by virtue of various possible combinations of hydrogen bonds, disulfide bridges and hydrophobic forces. These passages occur by means of nonlinear changes, or hopping, to overcome the energy barriers between one state and another. The proteins are thus dynamic, vibrating structures whose components undergo continual oscillatory movements, which take place over a time scale ranging from femtoseconds (10^{-15} s) to several minutes. The most significant vibrations in biological systems are of the order of nanoseconds [Hameroff, 1988]. It is very important to stress the fact that, in biology, many proteins (and also other chemical species such as lipids) are assembled in multimeric or polymeric groups. In these structures, cooperative, or collective, interactions easily occur, with the result that the vibrations may propagate themselves in *coherent* ways and, as such, may take on a biological-informational significance [Frohlich, 1988; Del Giudice *et al*., 1988b; Bistolfi, 1989].

Electromagnetic waves, even if of low energy and broad wavelength, are known to generate heat, when absorbed by biological matter. The question whether millimetric waves cause effects independent of absorption of heat, i.e. so-called nonthermal effects, has been the subject of lengthy scientific debate. The controversy regarding the existence of cell responses to low-energy waves is due both to the fact that the reproducibility of many experiments has proven difficult, and to theoretical objections that the energy of such weak fields would be less than the energy of the background noise due to the temperature at which the cells are studied (*thermal noise*). If we are to expect an effect of an electromagnetic field applied from the outside, this field will have to cause significantly greater changes than would in any event occur casually in biological systems even in the resting state (e.g. the continual opening and closing of ion channels, oscillations in membrane potentials and in many metabolic activities, etc., all these being processes which are in any event active at a certain temperature). Today, however, the existence of nonthermal effects of weak electromagnetic fields has been demonstrated in many experimental systems and may now be regarded as generally accepted [Kremer *et al*., 1988; Aldrich and Easterly, 1987; Magnavita, 1989; Tsong, 1989].

A major contribution to this issue can be found in a critical study published in *Science* [Weaver and Astumian, 1990]. These authors propose physical models according to which the cells are considered as detectors of very weak periodic magnetic fields and where the relationships between the size of the cell and the changes in membrane potential due both to temperature-induced fluctuations and to the application of electromagnetic fields are established. In the simplest version of the model, the calculation estimates at around 10^{-3} volts/cm the intensity of the minimum field to which the membrane macromolecules could be sensitive. However, if the model parameters considered take into account the so-called frequency “windows”, i.e. the possibility that certain responses occur only within a restricted frequency band, then the theoretical intensity necessarily proves to be several orders of magnitude lower (10^{-6} volts/cm), thus closely approaching the data from various experiments in cells and animals.

The growth of the nerve processes is guided by weak electric currents [Alberts *et al*., 1989]. When a nerve process lengthens in culture or even in connective tissue, at its apex a structure called a growth cone is formed, which appears as the expansion center of many long filaments (filopods) which look like continually slow-moving finger-like processes, making ameboid movements: some retract, and others stretch out, as if exploring the terrain. Within the filopods many actin filaments are to be found. The net vectorial shift of the

growth cone in one direction is followed by a lengthening of the nerve fiber (at an estimated rate of 1 mm per day). The direction of the movement depends on various local factors, such as, for instance, the orientation of the fibers of the connective tissue matrix, along which the growth preferentially occurs, and even the existence of specific membrane recognition systems between adjacent cells. The cells, however, are also powerfully influenced by electromagnetic fields: the growth cones of neurons in culture are oriented and direct themselves towards a negative electrode in the presence of low-intensity fields (70 mV/cm).

The cells have an ability to receive and integrate light signals, perceiving both their frequency and direction. This has been demonstrated by means of special phase-contrast microscopy equipment with infra-red light [Albrecht-Buehler, 1991]. 3T3 fibroblasts in culture extend the filopods preferentially towards light sources, the most effective being the intermittent ones in the 800-900 nm range with 30-60 impulses per minute. According to the author of these experiments, the cell receptor for the radiation is the centrosome.

There is also evidence that cell proliferative activity is influenced by electromagnetic fields, albeit of very low intensity (0.2-20 mT, 0.02-1.0 mV/cm) [Luben *et al*., 1982; Conti *et al*., 1983; Cadossi *et al*., 1992; Walleczek, 1992].

It is important to note that on the basis of the literature data available to date it is impossible to draw any definite conclusions as to the positive or negative, stimulatory or inhibitory effects of weak electromagnetic fields on cellular or molecular systems and above all as to doses and application modalities [Walleczek, 1992]. In fact, the bioactive electromagnetic signals used vary very considerably in terms of intensity, frequency, duration, and waveform (sinusoidal, square, sawtooth, etc.). Moreover, the effect may also depend on the biological status of the cells exposed [Cossarizza *et al*., 1989; Walleczek and Liburdy, 1990], indicating that mechanisms of very complex interaction between various different factors are involved.

Many enzymes and receptors appear to be sensitive to stimulations of a physical as well as a chemical type [Adey, 1988; Tsong, 1989; Popp *et al*., 1989]. The cell membrane, by virtue of its bioelectrical properties, is the site where influences of this type are most likely to be exerted [Kell, 1988], though other possible candidates are the large macromolecules organized in repetitive units, such as the nucleic acids [Popp, 1985], or the proteins of the cytoskeleton, particularly the microtubules [Hameroff, 1988].

The biological basis of the effect of magnetic fields on cells is highly complex and cannot be analyzed exhaustively here. The cell constitutes a typical electrochemical system, with a transmembrane potential difference (negative outside compared to inside) and a very large number of proteins endowed with electric charges of varying sign. According to the fluid mosaic model of the membrane (a model which is still valid, at least in general terms) in an ideal cell at rest, the proteins are distributed evenly over the membrane, but, in the presence of an electric field crossing the membrane, they undergo electrophoretic attraction or repulsion, tending to shift towards the poles which the cell presents in the direction of the electric field. A current of electrons or ions invading a cell flows around it, causing a movement of (electrically charged) proteins in the opposite direction.

The rearrangement of the position of the proteins on the surface of the membrane is not devoid of consequences, in that it favors contact between neighboring proteins and slows down contact between distant proteins [Chiabrera *et al*., 1984]. Since the functioning of receptors and membrane transduction systems depends on aggregations of proteins or at least on contacts between proteins, the consequences of the electric field for cell activation are easily imaginable. The aggregation phenomenon normally occurs in the case of a chemical signal, because the signal molecule may serve as a bridge between two or more receptors, which are mobile in the plane of the membrane.

Of course, this model is a very substantial simplification of what happens in reality, where the concentrations of calcium, magnesium, sodium, potassium and hydrogen ions come into play, as well as the possible direct effect of the magnetic field on the macromolecules of enzymes, receptors or the cytoskeleton (see below).

In molecular terms, it is known that many elements with receptor, structural and enzymatic functions are sensitive to changes in weak electromagnetic fields (see Table 7).

Table 7. *Molecular systems possibly interacting with electromagnetic fields*

Molecules	**Reference**
Photoreceptors	Alberts *et al.*, 1989
Chlorophyll	Alberts *et al.*, 1989
Receptors with 7 trans-membrane domains	Bistolfi, 1989
G-proteins	Adey, 1988
cAMP-dependent protein kinase	Byus *et al*., 1984
Protein kinase C	Adey, 1988
Lysozyme	Shaya and Smith, 1977
Receptors (aggregation)	Chiabrera, 1984
Chromosomes	Kremer *et al.*, 1988
Protein and lipid biopolymers	Hasted, 1988
Na^+/K^+ ATPase	Liu *et al*., 1990

Across the double lipid layer of the biological membranes, measuring approximately 40 Å in thickness, an electrical gradient of a few tens or hundreds of mV is established, which means something like 10^5 volts/cm. Theoretically this gradient should constitute an effective electrical barrier against minimal perturbations such as those created by low-frequency electromagnetic fields present in the extracellular membrane. In other words, the natural electrical activity of the membrane would constitute a kind of "background noise" which would prevent the possibility of perceiving minimal variations in potential. Very recent research, however, has shown that electromagnetic fields various orders of magnitude weaker than the transmembrane potential gradient are capable of modulating the actions of hormones, antibodies and neurotransmitters at receptor and transduction system level. This suggests that *highly cooperative processes* are set up, i.e. that repeated minimal variations cooperate to cause major movements. It is an effect similar to that which occurs when a bridge starts to oscillate whenever a body of men cross over it at marching pace, or when a glass breaks as a result of resonance.

The sensitivities observed in these biological processes of electromagnetic modulation are of the order of 10^{-7} volts/cm in the E.L.F. (extreme low frequency) range. Note, for example, that electric phenomena responsible for the EEG create gradients of 10^{-1} to 10^{-2} volts/cm [Adey, 1988]. Moreover, many of these interactions depend more on the frequency than on the intensity of the field, i.e. they occur only in certain *windows of frequency*, which would suggest the existence of *nonlinear* regulation systems far from equilibrium [Adey, 1988; Weaver and Astumian, 1990; Yost and Liburdy, 1992]. Similar sensitivities have been detected in a broad spectrum of tissues and cells, indicating that we are faced with a general biological property characteristic of cells.

The transfer of both chemical and electromagnetic signals from the external surface of the cell across the membrane consists in the transmission of conformational variations and oscillatory motions of proteins which have transmembrane domains (segments of the molecule). It has been claimed that a key role in this transmission is played by portions of proteins that have helical or folded-sheet-shaped fibrous structures

[Bistolfi, 1989]. Such structures are characterized by a substantial degree of order and by arrangement in repetitive sequences, as well as by the existence of hydrogen bonds between the amine residues of adjacent amino acids arranged longitudinally along the fiber. These protein structures are characteristic in their ability to *resound* according to nonlinear modes of vibration as a result of interaction with electromagnetic fields.

The prototype of this type of receptor is rhodopsin, the light receptor in the retina, which consists of 7 α-helixes arranged in orderly fashion transverse to the plane of the membrane on which it is situated. In this type of receptor-transducer, the excitation resulting from absorption of the photon is linked to the pumping of a proton and to the stabilization of a transmembrane potential.

It should be noted, however, that this structure with 7 α-helixes crossing the membrane is also found in an extensive family of glycoproteins involved in cell transmission systems coupled to G-proteins: the β-adrenergic receptors, the muscarinic receptors for acetylcholine, various receptors for neuropeptides, the receptors for chemotactic peptides in the white blood cells and even the mutual recognition systems in yeast cells involved in replicative fusion [Alberts *et al*., 1989]. It is therefore likely that these characteristic structural features render the transmission systems they are present in susceptible to electromagnetic modulation.

Studies conducted on electromagnetic modulation of collagen production by osteoblasts are consistent with this view. It has been demonstrated, in fact, that parathyroid hormone in osteoblasts binds to external receptors and activates the enzyme adenylate cyclase via the mediation of a G-protein. An electromagnetic field with a 72 Hz frequency and an electrical gradient of 1.3 mV/cm induced 90% inhibition of adenylate cyclase activation without interfering either with the receptor binding or with the enzyme itself. As a result, the inhibitory effect was attributed to blockade of the G-protein [Adey, 1988].

Cyclic AMP (cAMP) is an important element in controlling the function of many enzymes, particularly insofar as an intracellular increase in cAMP constitutes an activatory message for the protein kinases (enzymes which phosphorylate proteins). In precise experimental conditions of frequency and duration of exposure, the cAMP-dependent protein kinase of human lymphocytes has been inhibited by electromagnetic waves (field of 450 MHz modulated in amplitude to 16 Hz). Type C protein kinase, the involvement of which in important cell processes as well as in carcinogenesis is beyond doubt, can also be modulated by electromagnetic waves [data from Byus, cited in Adey, 1988].

The catalytic activity of the enzyme lysozyme is sensitive to electromagnetic waves (radiofrequencies from 0.1 to 150 MHz) [Shaya and Smith, 1977]. In these experiments, solutions of lysozyme were exposed, in the presence of submaximal doses of the competitive inhibitor n-acetyl glucosamine (NAG), to various electromagnetic frequencies supplied by an oscillator by means of a coil wrapped around a polycarbonate container of the enzyme solution. The main effect observed was a modification of the inhibition produced by NAG. Interestingly, specific frequencies (e.g. 40 MHz) increased the effect of the inhibitor, and other frequencies (e.g. 100 MHz) decreased the effect, enhancing the activity to the level of the uninhibited lysozyme, while yet other frequencies (e.g. 150 MHz) had no effect. Inspection of the whole range of frequencies between 0.1 and 150 MHz showed alternating peaks of stimulation and inhibition of the enzyme activity, without any apparent regularity. Subsequent measurements between 30 MHz and 50 MHz showed further fine details in the effects produced. Therefore, the relationship between frequency and activity appears to show a chaotic trend and fractal behavior.

According to Tsong and coworkers [Tsong, 1989; Liu *et al*., 1990], the conventionally known forms of intercellular communication, such as ligand-receptor interaction, are slow processes operating over short distances, but cells also need rapid forms of communication over long distances, with the result that it has been postulated that the various biochemical reactions, which are in any event necessary, are regulated by forces of a physical nature. Given that oscillating weak electromagnetic fields are capable of stimulating or suppressing many cell functions and that, from the thermodynamic point of view, this is possible only if mechanisms of amplification of the signal exist, it is postulated that the cell membrane is an amplification site.

The experiments carried out be Tsong's team indicate that a weak electric field (20 V/cm) is capable of activating the function of Na^+/K^+-dependent ATPase only if specific frequencies are simultaneously used, corresponding to 1 kHz for the pumping of K^+ and 1 MHz for the pumping of Na^+. These results have led to the formulation of the concept of "electroconformational coupling". This model postulates that an enzymatic protein undergoes conformational changes as a result of a Coulomb interaction with an electric field (or with any other oscillating force field with which the protein can interact). When the frequency of the electric field corresponds to the characteristic kinetics of the conformational transformation reaction, a phenomenological

oscillation is induced between different conformations of the enzyme. At the optimal field force, the conformations thus achieved are functional and the oscillations are utilized to perform the activity required, such as, for example, the pumping of Na^+ and K^+.

The organization of DNA in the chromosomes is affected by influences of an electromagnetic nature, as demonstrated in an extensive series of studies by Kremer and his coworkers [Kremer *et al*., 1988]. These authors used the model provided by giant chromosomes of insects (to be precise, the larvae of *Acricotopus lucidus*), which are easily visible and can be studied under the microscope. It is well known that when information has to be transcribed from DNA to RNA, the chromosomes (compact rods containing thousands of genes packed and stabilized by istonic proteins) have to partially decondense, showing puffs of genetic material issuing from the rod in the relevant segment. This phenomenon is strongly and significantly inhibited - in the sense that the puffs are much smaller - by irradiation of the chromosome with frequencies of around 40 to 80 GHz and outputs of only 6 mW/cm^2. The nonthermal nature of the phenomenon has been demonstrated by many control experiments.

7.3. Electroacupuncture

A substantial contribution to the understanding of homeopathy stems from the acupuncture tradition and, particularly, from experience with Voll's electroacupuncture, with the result that some mention of the practice is called for in this book.

Acupuncture today is more accepted, or better tolerated, than homeopathy in the medical world. In fact, though the theoretical basis derives mainly from Chinese medical thinking, the numerous instances of therapeutic success and the incontestable demonstration of the existence of acupuncture points and of a number of physiological correlates have made it easier for this approach to be integrated into western medicine [Di Concetto, 1989]. We are interested here in acupuncture only as regards its relationship to homeopathy, and particularly in view of the fact that certain aspects of the latter can be studied by means of electroacupuncture techniques [Leonhardt, 1982; Fuller Royal, 1990; Fuller Royal and Fuller Royal, 1991; Meletani, 1992]. Voll's electroacupuncture (EAV) constitutes a special synthesis between oriental medical thinking and western technology. Of Chinese acupuncture the "energy" conduction routes are used, such as the meridians and the points lying on them. Of the electronic know-how and procedures those used are the ones that enable cutaneous resistance to be measured in appropriate voltage and current intensity conditions.

7.3.1. Points and meridians

Before addressing the topic of EAV, we should first make a few brief introductory remarks about traditional acupuncture and the lines along which it has developed. The acupuncture points appear to be windows which give access to information on the state of functioning of specific organs and body systems. The electrical characteristics of the acupuncture points consist in a reduction of cutaneous electrical resistance. The cutaneous electrical resistance at these points is approximately 50,000 ohms, as compared to the rest of the skin, where it is above 200,000 ohms [Fuller Royal and Fuller Royal, 1991]. At the same time, it is known that to these points physical stimuli (needles, electric charges, pressure, laser beams, heat) can be applied, which are transmitted to organs and apparati and act as agents restoring the amount and balance of the "vital force" ("*Ch'i*" according to the Chinese tradition) which has been lost or become deranged (Yin-Yang imbalance).

From the points depart the *meridians* which "link" the body surface to specific organs and to an internal bioenergy network the nature of which is still largely unknown, not coinciding either with the nervous system or with the vascular or lymphatic circuits. It has been demonstrated [see review in Smith, 1988] that on injecting radioactive isotopes at acupuncture points, they travel along the meridians at a rate of 3-5 cm/minute and that the speed is reduced in the case of diseased organs. The propagation rate increases on stimulating the entry point with needles, electric current or light produced by a helium-neon laser. On injecting the isotope into other skin areas not coinciding with the acupuncture point, no appreciable propagation is observed.

Acupuncture meridians and points are known to be distributed nonrandomly on the surface of the body, and in many cases constitute areas with a so-called somatotropic distribution. For instance, in areas such as the tips of the fingers or toes, the ears, the sole of the foot, or the tongue, the points present themselves

according to precise maps of organs and systems, arranged with a certain degree of order. Also in this phenomenon the fractal geometry of the body structure and physiology may be thought about: a portion of the body contains a special kind of representation of the whole.

Despite this and other evidence, there is today still no satisfactory scientific theory to account for the effects of acupuncture. Everything we know, however, leads us to believe that underlying the functioning of acupuncture therapies is not simply a nerve reflex (there are no precise anatomical correlations), but a transmission of energy or information of an electromagnetic nature along communications networks of different types.

It has been claimed [Kroy, 1989] that in the philogeny and ontogenesis of living creatures there is a more ancestral cybernetic order than that based on the nervous system or on the humoral system (blood, hormones). This ancestral system is thought to be of an electromagnetic nature, because electromagnetic radiation is the most basic form of information present in nature. Electromagnetic signals have constituted (and still constitute) both the language of communication between atoms and molecules and the means whereby primordial organisms received a series of items of information on the environment (sunlight, other cosmic waves). There can thus be no doubt that living organisms have learnt to use electromagnetism as an information signalling system and thus as a means of communication between cells and tissues. According to the studies by Popp and coworkers [Popp, 1985; Popp *et al*., 1989], many biological systems are capable of producing, receiving and even of "storing" electromagnetic waves such as light.

The discussion of acupuncture could go on indefinitely. Whatever its mechanism of action, the procedure remains one of the main demonstrations of how biological and therapeutic effects can be achieved (cf., for example, the increase in endorphins, or the activation of the immune system [Chou *et al*., 1991]) by stimulation of a physical type (mechanical stimulus, weak electric currents, or laser light) and not by drugs.

7.3.2. EAV

As mentioned above, Voll's electroacupuncture is a diagnostic and therapeutic method which combines the basic principles of Chinese acupuncture and the possibilities of modern electronics. This method was introduced by the German physician Reinhold Voll in 1955, and indeed is still known as Voll's electroacupuncture (EAV) [Voll, 1975]. Later it was perfected and elaborated both in theory and in its applications. There are today many variants on the original procedure and many types of instruments capable of carrying out bioelectronic measurements - even of a type distinctly different from those of EAV - so much so indeed as to constitute an extensive area of what is termed *bioelectronic functional diagnostics*.

EAV and bioelectronics in general are widely used in Germany (the Society of Bioelectronic Medicine numbers a thousand or so members), but are becoming increasingly well known in Italy as well, particularly as a result of the work of naturopaths and homeopaths. Unfortunately, the virtually total lack of knowledge (or interest?) in this area in academic circles inevitably means that there is very little scientific research in this field, which, as we shall see, is highly promising.

This is not the place for a detailed review of bioelectronic techniques and procedures, for which the reader is referred to other studies in the literature [Voll, 1975; Leonhardt, 1982; Kenyon, 1983]. Here we shall confine ourselves to schematically outlining the basic principles and applications of EAV, with a particular view to understanding the relationships between EAV and homeopathy.

Thanks to the studies conducted by Voll and others, new measurement points hitherto unknown to classic acupuncture have been identified, and precise clinical correlations have been established between variations in cutaneous resistance and organ diseases; in addition, procedures have been identified for assessing the efficacy of drugs (both homeopathic and allopathic) by using EAV to test their effects. The task of EAV is thus primarily to provide an aid to diagnostics based not on the objective assessment of biochemical or anatomico-pathological alterations, but on the evaluation of the electrophysiological perturbations associated with the diseases. In this sense, there is no conflict between bioelectronic diagnostics and conventional medicine: "The basic opinions of clinical medicine and acupuncture appear at first glance to be opposed, but actually they complement one another to a very considerable extent; whereas the domain of classic medicine is curative medicine, that of EAV is primarily prophylactic. Prevention and cure, prophylaxis and curative medicine, both serve for the patient's well-being and to a greater extent if the two proceed in harmony, hand in hand, and complement one another without gaps" [Leonhardt, 1982, p. 312].

There are measurement points for all the major organs, for the tissue systems, for the bone, articular, vascular, nervous and lymphatic systems, as well as specific points for degenerative manifestations. Perhaps the most interesting aspect is that many diseases begin to manifest measurable disorders with EAV before exhibiting other clinical manifestations [Leonhardt, 1982].

The EAV measurement system consists essentially (Figure 28) in an instrument which delivers an electrical current of approximately 8 μamps and a potential difference of about 0.5-1 volt to the acupuncture points. The current is conveyed along a circuit consisting of a lead which terminates in a point electrode which is used by the operator to test the various points, and then by the patient who holds a cylindrical electrode in his or her contralateral hand from which runs a lead returning to an current measurement device and then to a generator. Connected up to the lead that runs to the patient is another lead which runs to a metal ampoule-holder, used for measuring the interference of drugs or other test solutions (see below). On some appliances the ampoule-holder is situated inside the measuring equipment itself.

Figure 28. Simplified schematic illustration of a circuit for the electronic measurement of the conductivity of acupuncture points [modified from Kroy, 1989].

If the reaction of the body or organ corresponding to the point tested is normal, the electromotive force measured should be approximately 0.8 volts. In practice, the voltage is set in such a way that the ohmmeter registers "50" on an arbitrary scale of 100 units. The current density in these conditions ranges from 5 to 11 μamps.

In the case of diseases affecting the organ corresponding to the point tested, an increase in cutaneous electrical resistance may be measured, and thus a reduction in conductivity. It should be pointed out, however, that a lowering of electrical conductivity is not found in all diseases; in the case of diseases characterized prevalently by inflammatory phenomena there may be an increase in conductivity.

To these characteristic variations in bioelectric indices, which are in themselves of by no means negligible diagnostic interest, another property of the EAV system must be added: in the presence of a lowering of the conductivity index, if an ampoule of a drug with a positive effect on the patient's energetic-informational equilibrium is inserted in the electrical circuit in the ampoule-holder connected up to the electrode via a lead, the point recovers its conductivity and the index returns to the normal level. Conversely, if a healthy subject is being tested and a toxic substance or substance to which the subject reacts pathologically (cf., for instance, allergens) is inserted in the circuit, a previously normal index will drop to pathological levels.

Some type of *interaction* or *interference* would thus be established between the compound inserted in the ampoule-holder and an apparatus (probably consisting in the system of points and meridians envisaged in acupuncture) which controls the cutaneous electrical conductivity in the body. There can be no doubt that, before being accepted within the framework of present-day physiological and pathological knowledge, such a claim requires further testing and considerable substantiatory documentation.

Research in this field today is oriented, on the one hand, towards optimizing the procedures in order to achieve maximum reproducibility of measurements and, on the other, towards establishing the mechanisms whereby changes in conductivity come about as a result of diseases or the effects of drugs and toxic substances.

In view of the importance which EAV may have both for an understanding of the mechanisms of action of homeopathic drugs, and in general in the future of medicine, it is advisable, in this field, too, to refer to a number of the (very few) objective and verifiable experiments conducted. One of the most advanced centers in studies of this type is the Department of Molecular and Cellular Biology of the University of Utrecht [van Wijk and Wiegant, 1989; van Wijk and van der Molen, 1990; van Wijk, 1991a; van Wijk, 1991b]. These researchers have verified that the parameter which best lends itself to objective measurements of changes in electrical conductivity at acupuncture points is not conductivity in the absolute sense (highly variable from one subject to another and influenced by the state of humidity of the skin or similar factors), but rather the phenomenon of *conductivity loss*: after applying the point electrode to an acupuncture point and maintaining constant pressure, within a few seconds a drop in conductivity is observed, as if a "charging" of the resistance of the point were taking place, or a "blocking" of the flux of electrical charges. This drop can easily be

recorded on paper, so as to be able to construct graphs which can be interpreted in both qualitative and quantitative terms.

Loss of conductivity is a phenomenon which always occurs, but is much more rapid in the presence of a pathological perturbation of the system (diseased organ, intoxication). The van Wijk's group has confirmed that, if to an ampoule-holder connected up to the system by means of a lead (see Figure 28) solutions of particular compounds to which the subject reacts are added, the conductivity loss phenomenon is modified, in the sense that it may increase or diminish. To put it in schematically oversimplified terms, the result would be that, if the compound is toxic, it causes a drop in the index on a point which was previously normal as regards conductivity, whereas if the compound is therapeutic it causes a recovery of the index on a point which was previously pathological. In any event, test results of this kind would provide a strong indication that the solution placed in series in the EAV machine-patient-tester-EAV machine circuit *interferes* with the transmission of the electrical current in the circuit itself.

Van Wijk is conducting studies to optimize the EAV system and, above all, in order to distinguish between subjective (e.g. operator biomagnetic ability or sensitivity) and objective factors. In a series of experiments he has carried out the following studies which are briefly summarized here. The tester takes preliminary readings on points of the skin to identify the point or points which show an appropriate electrical response (loss of conductivity) and a good response (recovery of conductivity) to a series of drugs tested by the operator by placing them in the ampoule-holder. Once the optimal point has been identified, the subject swallows 1 ml of liquid containing 0.1 µg of diphenyl. This substance is toxic, but when taken in small quantities, does not cause any particular harm to the body. A few minutes after swallowing the diphenyl, an increased rate of loss of conductivity is registered on the points identified, which is recorded in a tracing with three successive readings. The use of diphenyl in a healthy subject is thus a good method of obtaining repeatable variations which are not subject to the variability encountered in patients suffering from spontaneous diseases, which in a method such as this one prevents statistical assessment of the results achieved.

In these experiments [van Wijk and Wiegant, 1989; van Wijk, 1991a] the authors have demonstrated that this drop in conductivity was made reversible when an ampoule containing a homeopathic dilution of sulphur (*Sulphur* 12x) was inserted in the ampoule-holder. It should be noted that greater or lesser dilutions had no effect and that the effect was registered only if the *Sulphur* 12x was prepared by means of dilution and succussion and not by simple dilution. The authors have explained the phenomenon on the basis of the homeopathic law of similars, in that the symptoms of diphenyl intoxication are similar to those of sulphur intoxication. Clearly, this is an explanation of an analogical and not a scientific type, but the experiment reported nevertheless provides documentary evidence of a specific interaction of *Sulphur* 12x and diphenyl with the electrophysiological system of the human body, as assessed by EAV.

In a subsequent communication, van Wijk reported that the EAV test also works in double-blind conditions, though less efficiently than in an "open" trial (i.e. when the operator or tester knows the type of ampoule inserted) [van Wijk, 1991b]. After recording the conductivity loss due to diphenyl, sealed ampoules of *Sulphur* 12x were inserted in the ampoule-holder and another set of three tracings was recorded. Placebo ampoules (dilutions of alcohol) were then inserted in the ampoule-holder and the conductivity loss rate was re-measured. The operation was repeated many times, first "open" and then "blind", in the sense that an independent observer inserted the ampoules into the ampoule-holder without telling either the tester or the patient. At the end of the experiment the tracings were processed as conductivity loss rate (in µamps/sec) and were compared for the true drug (in this case *Sulphur* 12x) versus placebo.

From these experiments it emerged that *Sulphur* causes recovery of conductivity (i.e. it prevents the loss of conductivity in the first few seconds after application of the point electrode) induced by diphenyl much more than placebo does. In the "open" experiments the difference is striking: with *Sulphur* in the ampoule-holder the loss of conductivity is from 0 to 0.25 µamps/sec, whereas with placebo it is from 1 to 1.75 µamps/sec. In the double-blind experiments, the difference was less marked, in that several false-positive tests were registered (i.e. the placebo had an effect) as well as several false-negatives (i.e. *Sulphur* had no effect), but on the whole the difference was highly significant (see Table 8).

Table 8. *Effect of Placebo and Sulphur 12x on loss of conductivity induced by diphenyl in a series of double-blind tests*

	Placebo	**Sulphur 12x**
No effect	35 tests	32 tests
Effect (blocking of conductivity loss)	13 tests	39 tests
Statistical difference: $P < 0.005$		

The use of EAV and of similar equipment in the detection of allergies has also been described by others [for a review see Fuller Royal, 1990; Fuller Royal and Fuller Royal, 1991]. The data obtained by means of electrodiagnosis of food allergies have been found to correlate with those obtained using better known methods such as RAST, skin tests, and alimentary provocation tests. Other studies, conducted double-blind [Ali, 1989], have shown that, in subjects suffering from allergies, electrodiagnostic testing shows a 73% correlation with levels of IgE antibodies specific for pollens and house dust.

The EAV test appears to function both with homeopathic and allopathic medicines, being used, for example, to assess the degree of pancreatic damage in diabetic patients and to establish an appropriate insulin dosage [Tsuei *et al*., 1989; Lam *et al*., 1990]. One thing is certain: if things were really like this, it would be an important field for development also in the allopathic context, in view of the fact, amongst other things, that the equipment required for such investigations is extremely simple and relatively inexpensive.

The mechanism whereby this interference phenomenon comes about is still obscure, in that very little research has been done to date in this field. In any event, one can hardly fail to appreciate the importance of the phenomenon described, which, once confirmed and accepted, would lead to conclusions such as:

a) The human body presents an increased electrical conductivity of the skin on the acupuncture points.

b) This conductivity is not stable, but is influenced by the state of health or sickness of the subject as a whole and of the organs of the body, which, according to the acupuncture concept, are linked to each of the points.

c) The electrical conductivity can be altered (both positively and negatively) by the introduction of toxic substances or drugs.

d) The alterations of electrical conductivity can be induced not only by the swallowing of the substances themselves, but also by placing ampoules containing solutions of the same substances in an ampoule-holder connected up by a wire to the system.

e) The EAV system makes it possible to demonstrate that the molecules in a solution possess the property of long-range interaction with electromagnetic frequencies.

f) Both homeopathic and allopathic drugs can be tested for their reactivity with the patient, just as allergies to particular substances can be detected by EAV.

Notwithstanding these positive results, many aspects of the EAV methodology are still uncertain, and its reliability as a diagnostic tool should be treated as hypothetical. The most controversial issue has to do with the role of the tester in the overall procedure: it has been shown in “blind” experiments that the tester is somewhat affected by the patient in the fine tuning of his muscular activity and the change in the muscular force applied to the electrode may change the current flux [van Wijk and Wiegant, 1994].

In a different, though related series of experiments, van Wijk's group joined forces with the Endler and Haidvogel group, who had performed the experiments on the effects of high dilutions of thyroxine on frog metamorphosis mentioned in Chapter 4, Section 1. In this latest series of tests, the authors [Endler *et al*., 1994a] prepared high dilutions of thyroxine (T_4 30x) and, as controls, high dilutions of water (H_2O 30x), according to the rules of homeopathy. The dilutions were sealed in glass ampoules, and codes were applied to

the ampoules by independent researchers from the Institute of Zoology of the University of Graz, with the result that the tests were performed blind. The ampoules - obviously sealed - were immersed in different containers in which the animals were being bred at a very precise stage of development (immediately after the complete appearance of the rear limbs and prior to the loss of the tail).

The experiment consisted in counting the number of small frogs that climbed the walls of the breeding containers, and out of the water. The results (reproduced by five different researchers and making a total of more than 3000 observations) showed that the frogs from the container in which the T_4 30x ampoule was immersed climbed out of the water with a significantly greater frequency than the frogs treated with the H_2O 30x ampoule. Assays of thyroid hormones and iodine on the ampoules and on the ampoule washing fluid ruled out the presence of accidental contamination of the ampoules used in the test. However incredible these results may seem, we mention them here both in order to illustrate the problems with which researchers in the field of homeopathy are coming to grips and on account of their suggestive analogies with the results mentioned above in connection with the EAV tests.

Similar results have been confirmed by the same research team in a more recent communication [Endler *et al*., 1994c].

Other clinico-therapeutic experiences deriving from particular applications and variants of EAV have to do with the use of equipment such as MORA (from the initials of its inventors, Dr. Morell and his colleague, the engineer Rasche), for which, however, the reader is referred to other more specific texts [Meletani, 1990].

All these observations, if confirmed and consolidated by further evidence and testing, would indicate that:

a) Information of a nonmolecular nature remains impressed in the water in the process of dilution and dynamization.

b) This information may pass from an ampoule to the body by direct or indirect contact via the water of biological fluids.

c) In suitable experimental conditions, this information may bring about a certain effect which appears to be somehow related (by similarity or antagonism) to the effect of the initial preparation with which the dilution has been prepared.

As regards the diagnostic aspect at least, it is hard to see how electroacupuncture can fail to integrate with conventional diagnostics, being perhaps an extra means of gaining information about the functional disorders of organs or tissues, on previous infections (immunity) or infections in progress, on allergies or forms of food intolerance, on the particular reactivity of a patient to potentially dangerous drugs in cases of idiosyncrasy. Those who use these procedures stress the concept of "functional diagnostics", meaning by this the possibility of detecting homeostatic alterations early compared to anatomico-pathological alterations [Leonhardt, 1982]. If this were true, EAV could be complementary to traditional diagnostics and, if adequately controlled and verified, may prove helpful to the doctor in orienting him towards trying to locate and identify diseases in preclinical stages. Having extra data, even if not entirely reliable, does not in itself oblige us to regard it as decisive, but may serve in some cases to substantiate diagnoses or as a guide to therapy.

7.4. High dilutions, chaos and fractals

After what we have said in connection with complex systems and chaos (Chapter 5, Section 7), and after citing theories and trials in favor of the existence of metamolecular biophysical phenomena, we shall attempt a brief résumé of the situation here in this section.

First of all, we should recall what we have said in connection with the instability of the dynamic systems of the body. The existence of chaos and forms of fractal geometry is also of substantial importance for homeopathy. In fact, the hypothesis currently taking shape in this context claims that the homeopathic remedy, containing a set of specific items of information for a given patient, *may act as an attractor* in a pathophysiological situation with a tendency towards chaos and towards disorganization (disease). When a system is in a state of dys-equilibrium controlled by many factors, i.e. when it presents a behavior pattern characterized by complexity and chaos, a *small amount* of energy should be enough to make it shift one way or the other. The nearer one is to the bifurcation point, and the greater the freedom of choice, the lower will be the energy needed to shift the system in one direction or another.

This concept is well illustrated by going back to the mathematics of dynamic systems and of chaos. Considering the Verhulst algorithm, which has already been presented above (Chapter 5, Section 7.1), it can be demonstrated that the chaotic evolution of the nonlinear "homeostatic" function

$$A_{n+1} = A_n + A_n\, k\, (A_{max}-A_n)$$

can be changed to a more orderly evolution by means of very minor changes in the parameters such as changes in the coefficient k or of A_{max}. In fact, Figure 29A shows that a modification of k from 0.56 to 0.57 (i.e. 0.01) induces a dramatic shift from a totally chaotic attractor (where all the values from approximately 1 to 7 are allowed) to a situation where the A values resulting from the iteration are "confined" in three bands of values, arranged in the following sequence: low (A = about 1), medium (A = about 3), and high (A = about 7). The small change in k has forced the function into a new attractor, with characteristics of lower chaoticity, higher predictability, and better harmony. It is worthy of note that in the example given here, this effect is produced only by a small change in k. If the change is too marked, namely 0.02 as in Figure 29B, the function continues to present a chaotic trend.

Figure 29. Effects of small changes of a constant coefficient in the chaotic behavior of a complex function. The panels show successive changes in the variable "A" in the iterations of the Verhulst algorithm (the formula is in the text). A_{max} and the (initial) A_n in all cases are assumed equal to 5.0 and 1.0, respectively. The changes in the coefficient k introduced at iteration n = 34 are indicated in the panels.

Figure 29C shows that the modification of k from 0.56 to 0.55 (i.e. a 0.01 decrease in coefficient instead of the 0.01 increase as in Figure 29A) does not affect the chaotic behavior of the attractor. This indicates that the *direction* of the change is not indifferent: in other words, to obtain a specific and "qualitative" change of attractor, we need information that may *direct* the change in the desired way. This information cannot be wholly deduced from the appearance of the chaotic system: for certain values of k, a further increase may cause a return of order, while for other values of k, a further increase may cause an increase in chaos or the onset of chaos starting from an ordered situation (see, for example, Figure 16D - 16E). Owing to the complex behavior of chaotic systems, the outcome of a change in k coefficient cannot be wholly predictable, but has to be tested experimentally. Only experience provides sufficient information to predict the behavior of complex systems in the proximity of the bifurcation points.

In brief, then, it may be postulated that the homeopathic drug, containing little of the material of the original solute (or none of it, according to the dilution) possesses a high "information content" for the specific case, thanks to the matching of the symptoms ascribed to the drug itself and those of the patient (law of similars). This information content will be capable of forcing the body homeostasis into a different attractor, or a different system of attractors, *in the specific direction dictated by the remedy*. In other words, this information, supplied in critical conditions of sensitivity of the system, will represent an adjustment towards a given type of behaviour, something like a "catalyst of order", or "pacemaker".

The information received, amplified and processed by one or more regulatory systems, might counteract the disorder induced by the pathological factor that has perturbed the normal homeostasis of the body. If we are referring to the field of high dilutions, it is clear that such "attractive" information must be based on the permanence of the image of the original compound, or of an image related to it. What we mean by "image " here is not merely spatial geometry, but potentially a spatio-temporal order as well in the form (form = in*form*ation and memory) of a certain oscillation frequency of the molecular dipoles or proton exchanges at hydrogen bond level.

It has been seen, in earlier sections of this chapter, that this "permanence of information" is now more than a simple hypothesis, even if its physical basis still remains highly uncertain. It has been demonstrated that such a phenomenon is *not absurd* in principle and that various models have also been proposed by competent researchers in the field.

It is worthwhile here re-examining, in particular, the problem of metamolecular information from the point of view of chaos and fractals. The relationship between these new mathematical theories (and experiences) and homeopathy can hardly fail to be extremely close both because the communication of information from the solute to the solvent is nothing other than the transition of water from chaos to order,

and because the dilution/dynamization processes may be regarded as resembling fractal dynamics. Other investigators have pointed out how the language of mathematics of nonlinear dynamics contains concepts that describe homeopathic observations [Garner and Hock, 1991; Shepperd, 1994].

The following outline, however, lays no claim to being a fully fledged scientific model, but only a fairly speculative dissertation. In this context extensive use will be made of analogical reasoning, which proves particularly useful in such uncertain and complex fields.

7.4.1. Transition from chaos to order

On dissolving a given compound in water, the compound "informs" the collectivity of the water molecules near to it, organizing them in such a way that as a whole they take on a configuration that reflects that of the compound itself. This is well known in chemistry, being due essentially to hydrophobic forces and to weak forces of attraction and repulsion of charges. It has also been seen that the nearest water molecules, thus reorganized, communicate in turn, via hydrogen bonds and probably also via electromagnetic vibrations related to the coherent motion of the dipoles, with other nearby molecules and so on up to a certain distance.

These modifications of the water are, however, a measure of "transfer of form", without this necessarily involving any chemical change in the water molecules *per se* (at least as regards the molecules not immediately in contact with the compound in solution), consisting only in a broad-ranging reorganization. According to the conventional view, successive dilutions entail a progressive reduction in the number of molecules of the solute up to its disappearance and up to the simultaneous disappearance of the reorganization form of the water already produced.

In homeopathic theory, by contrast, the solute, thanks to the succussion at the time of dilution, is believed to communicate an "excess" of information to the water compared to that strictly related to the molecular concentration of the solute itself. The reorganization of the molecular relationships is thought to take on a trend similar to that considered apropos of the Bénard cells (Chapter 5, Section 8.1): the water molecules, subjected to a given flow of energy, take on collective behavior patterns; in other words, a *coherence regimen* is set up in large domains of the water molecules. Obviously, these collective behavior patterns do not consist in macroscopic movements of masses of water, but in coherent vibrations of the molecular magnetic dipoles or of the protons involved in the hydrogen bonds between numerous adjacent water or ethanol molecules. Moreover, how this regimen can be maintained over time is somehow bound up with the possibility that the collective movements may in some way be isolated from the surrounding molecular chaos. As illustrated above, there is no univocal theory on this point, but the hypotheses put forward in earlier sections of this chapter (superradiance, NMR) appear suggestive.

7.4.2. Fractal dynamics

Various experiments have suggested that the biological activity of homeopathic dilutions does not diminish or increase regularly with increasing dilutions, but follows a "pseudosinusoidal" trend, with peaks of activity and troughs of inactivity. The most evident example is in Figure 1, taken from the famous experiment performed by Benveniste's research team [Davenas *et al*., 1988], but similar trends have also been reported by others [Poitevin *et al*., 1985; Davenas *et al*., 1987; Boiron and Belon, 1990; Poitevin, 1990; Sainte-Laudy *et al*., 1991; Garner and Hock, 1991]. It can be seen that the activity causing basophil degranulation is present at the 9 log dilution (corresponding by and large to the homeopathic 9x dilution), and then drops to a minimum level at the 11 log dilution, only to pick up again and rise to a peak at the 15 log dilution, thereafter descending again, and so on. It will be noted that the recurrence pattern of the peaks is not regular, but chaotic and unpredictable, but at the same time it must be admitted that this recurrence exists, i.e. that the effective information re-presents itself after a number of log dilutions. According to the logic of current chemical reasoning, such a trend appears thoroughly and quite definitely absurd, but in the light of new knowledge of chaotic phenomena and the nonlinearity of many biological mechanisms perhaps some kind of underlying logic can be traced.

If we are prepared to give credence to such paradoxical results, one question inevitably springs to mind: how can information disappear and then reappear? Where did the information go in the mean time, while the inactive dilutions were being done, between one peak and another? To answer this question the fractal "line

of reasoning" may come in handy. In fact, if we are to take the results of the experiments seriously, we have to admit that the information of the compound dissolved is not completely "dissipated" in the course of the successive dilutions, even when the dilutions are inactive. Evidently there exists some mechanism of transmission and storage of the information in the course of the dilutions such that the next dilution following an active dilution may give rise to a form (or vibrational frequency) differing from the previous one (and for this reason inactive), but capable, after a few steps of further diversification, of causing the original (active) information to "reappear". The dilutions, then, would not produce a loss of information (increased entropy), but only a change and variety of forms, which in turn may regenerate the starting form. Such behavior is reminiscent of what we have seen apropos of the mathematical iterations that generate fractals (see Chapter 5, Section 7, and Figures 16 and 17).

The repetitive waves of appearance and disappearance of activity may therefore represent chaotic oscillations of the result of a process of transfer of information from one dilution to the next. This, then, would be a phenomenon similar to the "recurrent regularity" typical of chaotic systems and fractals (see Chapter 5, Section 7).

If this is how things were, it would be easier to put into perspective the problem of the poor reproducibility of results, often seen in experimental trials in this field. The low reproducibility may depend on many factors related to the materials and methods used, but it is quite clear that if we postulate the existence of intrinsically chaotic mechanisms in the process of information transfer, the nonreproducibility should be viewed in a new light. In fact, wherever chaos and complexity play a significant role it is only to be expected that *minimal variations in the conditions of the experiment will express themselves in the form of substantial variations in the results* (cf., too, the discussion in Chapter 5, Section 8).

For instance, anyone wishing to repeat an experiment such as the one conducted by Benveniste's team (see Figure 1) should absolutely not expect to find the same activity peaks and inactivity troughs for the same dilutions, nor to observe the same phenomenon in all the experiments performed. On the other hand, there has to be a certain type of reproducibility in scientific research (e.g. the appearance of peaks at certain dilutions, at least in a significant number of cases and the nonappearance of peaks in control experiments with untreated water). This has been confirmed by Davenas (personal communication) and by other experiments reported in Chapter 4, as well as by EAV tests.

The hypothesis has been advanced [Gardner and Hock, 1991] that the successive dilutions and dynamizations performed in the preparation of a homeopathic remedy introduce an element of *information gain*, as is observed in the Mandelbrot sets with successive iterations (see Figure 17). It is suggested that low dilutions (few iterations) produce poor definition of details and carry rough and imprecise information, whereas high dilutions (many iterations) are characterized by better definition of details, as can be seen in the profiles of the Mandelbrot sets. If the dilutions/iterations are few, the image is "blurred", whereas, if they are repeated many times, the image is precise and, surprisingly, "reappears", i.e. it is reproduced in detail in subsets and in subsets of subsets. The image of a certain structure (in the case of homeopathy, the mother tincture) reappears in a "similar" form in successive dilutions, practically to infinity.

Such a phenomenon may basically be responsible for the fact that in classic homeopathy the high dilutions are regarded as more specific and profound in their therapeutic effect if there is perfect matching of the symptoms of the patient and the remedy, i.e. if the "*details*" of the analogy have emerged clearly from the homeopathic history-taking. In practice, the fewer the symptoms shared by the patient and the remedy, the lower will be the dilutions used; the more symptoms they have in common, the higher will be the dilutions prescribed.

Our aim in referring to these aspects is also to stress that a scientific approach to homeopathy in future will require the joint contribution of several disciplines, including mathematics, geometry and computer sciences. In general terms, the suggestions we are making here emphasize the fact that those researchers who are prepared to engage in the study of the unsolved, complex problems of biology and physics (including the study of homeopathic high dilutions) must begin to include the dimensions of chaos and the fractals in their conceptual, and possibly also in their experimental armamentarium. Chaos should appear less daunting to scientists today than it did in the past, because, thanks to the discovery of fractal geometry, we are beginning to come to grips with a number of rules of behavior which allow a certain degree of predictability.

7.5. Discussion on high-dilution homeopathy

We shall attempt here to summarize the main points dealt with in order to construct a number of hypotheses which constitute the frame of reference for putting homeopathy into rational and experimentally viable perspective, particularly that part of homeopathy relating to the use of high (metamolecular) dilutions. Hypotheses are essential to the evolution of knowledge. Of course, one has to guard against presenting them as certainties. Only a patient, multidisciplinary effort will contribute towards clarifying, at least in part, the mysteries of the infinitely small. The hypotheses set forth here also refer to theories proposed by other authors [Vithoulkas, 1980; Tetau, 1985; Callinan, 1986; Rubik, 1990; Popp, 1990a; Popp, 1990b; Ullman, 1991a; Schulte and Endler, 1994].

The main difficulty of homeopathy using dilutions which enter into the "metamolecular" domain consists in the fact that it apparently contradicts the biomedical model dominant today, namely the biochemical-molecular model. In a homeopathic preparation, very few or no molecules at all of the drug are present, and thus it proves impossible to explain, in terms of present-day pharmacological knowledge, how such a preparation can have any effect.

Nevertheless, a new vision of matter and life, more compatible with the possible *modus operandi* of homeopathy, is emerging on the frontiers of science, particularly from the fields of quantum physics and mathematical theories and research which have yet to be systematized. Organisms are seen as highly regulated, complex, dynamic systems which display a characteristic meta-stability around certain homeostatic levels. This meta-stability is the net result of continual oscillations, rhythms, networks, amplifications and feedback cycles. Living systems are "suspended" between order and chaos; they partake of these two fundamental characteristics of matter and exploit them in a manner designed to promote survival. Order and chaos are to be found at all levels of homeostasis, from the molecule to the human mind. We cannot see how these new perspectives can fail to have an impact on the new orientations and trends in medicine. Medical theory, methodology and technology have always proceeded hand in hand with the general scientific theory and socio-economic situations of the times.

Homeopathy is witnessing a revival in the present age, marked, as it is, by a staggering increase in scientific knowledge, accompanied by the awareness of a substantial degree of indeterminacy of reality. This is not tantamount, as many people are inclined to believe, to resorting to para-psychological or esoteric paradigms to escape the anguish of chaos and lack of trust or confidence in the modern health system. It is instead more likely that most of the success of homeopathy depends precisely on its original basic assumptions, which are at one and the same time realistic in theory and empirical in content.

Realism in this case coincides with humility and practicality; this was expressed by Hahnemann himself when he said, not without a sense of the paradoxical (for which he was to pay dearly): "Of such learned reveries (to which the name of *theoretic medicine* is given, and for which special professorships are instituted) we have had quite enough, and it is now high time that all who call themselves physicians should at length cease to deceive suffering mankind with mere talk, and begin now, instead, for once to act, that is, really to help and to cure" (note to paragraph 1 of the *Organon*). Certainly, we cannot fully endorse this statement today (otherwise we should never have set about writing this book). It is also true, however, that the arguments discussed and documented here appear to bear witness to the *substantial soundness* of Hahnemann's position, which methodologically takes into account the complexity of the human being and of human disease.

7.5.1. Oscillations and resonance

We have extensively illustrated the fact that living creatures are open systems far from equilibrium, subject to regulatory apparati which cannot necessarily be represented by linear equations, and thus are capable of perceiving minimal perturbations, particularly when they are predisposed to such sensitivity, possibly by the very pathological process itself. New evidence from electromagnetism studies lends support to the possibility that living systems respond to extremely weak magnetic fields, and particularly to specific frequencies. At the same time, studies regarding the physics of water suggest, or at least do not rule out, the possibility that water itself may act as a store and vehicle for electromagnetic oscillations. The tradition and new experimental evidence stemming from acupuncture and related techniques demonstrate that an individual with a molecular or functional disorder presents an imbalance of electromagnetic homeostasis which appears to be exploitable for diagnostic purposes and reversible if treated by specific stimulation.

Disease may therefore be regarded not only as a functional or molecular-structural abnormality, as in the classic view, but also (and not by way of contrast) as a disturbance of an entire network of electromagnetic communications based on long-range interactions between elements (molecules, nerve centers, organs, to mention but a few) which oscillate at frequencies which are coherent and specific and thus capable of resonance. This would be a *disturbance of internal oscillators and their communications*. Our knowledge is still too scanty to say whether or not these oscillators can be identified with certain nerve centers in particular (the ability to oscillate at characteristic frequencies is typical, though not exclusively so, of nerve centers) or with the collective behavior of nerve centers and/or other tissues or cells.

A disturbance of oscillation and of the communication associated with it may be brought back to a state of equilibrium by means of *syntonization or tuning, i.e. by means of a change in frequency imposed by interaction with another oscillator.* According to this notion, the homeopathic remedy might act in the patient as an external guide frequency.

The phenomenon of resonance is well known in physics, where it occurs in many fields: acoustics, mechanics, and electromagnetism, as well as nuclear physics. By virtue of this phenomenon, a system which is characterized by its own oscillation frequency can enter into vibration if stimulated (subjected to sound waves, electromagnetic waves, or mechanical vibrations according to the nature of the system) by frequencies close to those peculiar to the system itself. If the system is already oscillating, the resonance may greatly increase the amplitude of the oscillation, whenever the waves overlap, while the opposite may also occur, namely an arrest of oscillation, if the interaction is between two waves of the same frequency but opposite in phase. Of course, biological systems are characterized by very complex oscillatory frequencies, in keeping with the complexity of their components. For resonance phenomena to occur, the frequencies do not need to overlap exactly; it is enough for there to be matching of one or more harmonics (harmonics are the simplest components into which periodic functions produced by their overlap can be broken down); the harmonics of a given periodic system all have frequencies which are multiples of the fundamental frequency, called the first harmonic.

Resonance, then, is a way whereby information is transmitted between two *similar* systems (as regards vibrational or harmonic frequencies) without structural modifications and without the passage of matter. These linkage phenomena between oscillators, which generate synchronism and cooperativity, are of paramount importance in many physiological functions, particularly in the nervous system, but also in the cells regulating cardiac rhythm, in the cells secreting insulin in the pancreas, in the ciliated epithelia, and in the involuntary contractions of smooth muscle [Breithaupt, 1988; Engel *et al*., 1992; Strogatz and Stewart, 1993].

Therefore, a dynamized and potentized homeopathic drug might be regarded as a small amount of matter containing elements oscillating in phase (coherently), capable of transmitting these oscillatory frequencies, via a process of resonance, to biological fluids (in turn mostly made up of water), but also to complex "metastable" structures, subject to nonlinear behavior patterns and capable in turn of oscillating (macromolecules, α-helixes, membranes, filamentous structures, receptors). There would thus be the possibility of a link between drug frequencies and oscillators present in the living organism perturbed by the disease.

Even signals which are extremely small, but which are endowed with highly specific information and are capable of resounding in unison with the recipient system, could act as regulators, if it is admitted that the dys-regulated system or systems are in a state of precarious equilibrium, near to the "*bifurcation*" point, where the choice whether to move in one direction or the other is related to minimal fluctuations on the border between order and chaos. The new concepts emerging from chaos studies tell us that at this "border" minimal variations in the conditions of the system (such as those induced even by a very small oscillatory resonance) may play a decisive role in the subsequent evolution of the system itself. In a variety of systems, the "butterfly effect" may be used to control chaos, on condition that the parameters to be controlled and changed are well known [see also Shinbrot *et al*., 1993; Schiff *et al.*, 1994; Moss, 1994].

7.5.2. Bifurcations

Where are these "bifurcations" sensitive to minimal doses and, presumably, to metamolecular information? They may be found in the behavior of any complex system, from single molecules to cells and to the whole body. Here we consider specifically the bifurcations occurring in the dynamic progression of diseases.

As illustrated previously (Chapter 5, Section 1 and Chapter 6, Section 2.4), the story and intimate nature of a pathological process present various phases or aspects which integrate one another in sequences in time and space. If we are referring to the majority of diseases, which are not exclusively of genetic origin, what usually appears as the "disease" according to the traditional diagnostic criterion is the last phase, consisting in precise biochemical and anatomical abnormalities. Before this, however, there are at least three other phases:

a) *From health to the initial disorder*

Starting from an ideal state of health, we have the very first stage in which an initial disorder, mostly nonapparent apart from a number of very indistinct symptoms or variations in very subtle parameters, makes the body susceptible to perturbations induced external agents. The subject cannot be defined as a sick person, but is more predisposed to falling sick than normal and has a tendency to fall sick. In this stage we could, for instance, include those who are subject to overwork (stress) or to an unbalanced diet, those who smoke, who are exposed to low doses of ionizing radiation, or who present particular genetic characteristics making them statistically "at risk" (heterozygous carriers of autosomal recessive diseases, a number of HLA groups, race, etc.).

To what extent this disorder is "normal", in the sense that it is a simple reversible oscillation of a state of equilibrium, and to what extent it is "pathological", in the sense that it generates disease in the presence of other perturbing factors, is an extremely subtle and hazy issue, so much so indeed that the same situations, which may even be quite severe, are supported as a normal burden of life by some people, whereas they are regarded as serious diseases by others (often defined as imaginary or psychosomatic illnesses). Clearly, at this level the balance between normal and pathological is extremely precarious, and the subsequent course of the disease can come down on side or the other according to shifts in minor factors.

It has been said (Chapter 5, Section 8) that the body may be seen as a system of flux and that, in the domain of complexity, variations in the flow of energy can induce turbulence:

Complexity + energy flow ----> turbulence

Diseases, in the initial stages, can be regarded as turbulence phenomena in the metastable equilibrium that we call health. The order of the system changes, but the parameters, matter and energy making up the system do not necessarily change with it. We have seen and understood that disease presents a component related to imbalances in the electromagnetic homeostasis of the body, based on forms of communication or regulation mediated by frequency and vibrational signals. View from this angle, the homeopathic drug, which is rich in information though lacking in material substance, might positively act as an order-carrying factor and guide the body towards a new or pre-existing pattern of behavior.

b) *The reactive phase*

A second bifurcation is to be found in the reactive phase of homeostatic biological systems. As extensively documented above, these systems - particularly the inflammatory and immune systems, but also the liver detoxification systems, the hemostatic system, and others - are "two-faced", i.e. they bring about healing, but they also cause damage.

To what extent, in each individual case, the damage prevails over the restoration of the state of health or vice versa, depends on subtle variations in the behavior of the homeostatic system itself. In particular, the fate of the reaction depends on the "choice" that the system has to make between the price to pay, in terms of toxicity and suffering, and the guarantee of success of the operation in terms of survival of the body. For instance, in the presence of a lesion of the surface of a blood vessel, the hemostatic system comes into action to block the risk of hemorrhage and to initiate repair (clotting, platelet aggregation, increase in connective tissue and vascular musculature). Yet, through the same effector mechanisms a pathological event can occur: the hemostatic system entirely blocks the circulation of the blood in the vessel (thrombosis, atherosclerosis).

What is it that "tips the scale" in favor of the positively-directed action rather than the unnecessary and frankly pathological one? It is the complexity of the multiplicity of mechanisms involved. A "choice" of this type depends, in fact, both on the individual elements involved (receptors, concentration of mediators, presence of exogenous chemical substances) and on the type of coordination available, on a "centralized" control system that assesses the information coming in from the various regions and elements involved and regulates accordingly the various responses.

Thus, at the level of such a bifurcation, the outcome of the reaction may depend on an item of information that is *significant in terms of the coordination* of the reaction system or systems. Since such coordination is guaranteed by cybernetic networks such as the nervous and hemato-hormonal systems, but also by the acupuncture regulation system and perhaps by other information networks as yet to be identified (exchanges of frequencies by means of water or biopolymers, cf. Bistolfi, 1989), the result is that an item of metamolecular information that reaches these systems and is decoded by them may be useful in the optimal "choice" of reaction to the damage.

c) *Adaptation?*

A third phase of the disease process, in which another very critical moment of decision presents itself, is when the reactive systems fail to cope with the situation and rapidly restore the original state. At this point adaptation may set in, which is a semipermanent modification which, on the one hand, reduces the symptoms, but, on the other, may lead to various consequences, including deposition of toxins, hyperplasia, shifting of the receptor sensitivity threshold and biochemical and anatomical changes that "defer the problem" for lengthy periods or shift the pathological consequences from one organ to another. This has already been mentioned in the chapter on the complexity of diseases (Chapter 5, Section 5.1). Adaptation makes it possible to *live with* the disease, but also constitutes, in a certain sense, a renunciation of complete healing. At this point, too, homeopathy and homotoxicology, as therapies aimed at "re-arousing" the reactive capacity, may be of decisive importance.

Homeopathy should therefore act on the initial "decision-taking" levels of the body's repair and defense systems. When a disease reaches the stage where gross biochemical and anatomical consequences of the disease process are present, we are entering a field in which there would appear to be a much greater indication for the use of strong therapies such as surgery, replacement therapy, or the use of drugs at high doses, though even here a possible contribution of homeopathy should not be ruled out (provided at least some of the homeostatic control systems can intervene).

Even as referring to the diagnostic sphere, it is clear that the more a disease claims attention in terms of biochemical and anatomical abnormalities, logically the greater will be the tendency to resort to laboratory investigations and diagnostic imaging techniques, whereas a homeopathic "diagnostic work-up" aimed at capturing the subtle differences in personality and symptoms between one patient and another would make very little sense. Conversely, however, conventional diagnostic means can achieve very little within the framework of the initial subtle changes in complex homeostatic equilibria, or, even if they manage to pinpoint individual variations in biochemical or functional parameters, yield no criteria for "reconstructing" the picture as a whole and thus for implementing a complete therapy.

In conclusion, then, homeopathy is not opposed to the conventional approach even in the context of these considerations: homeopathy is concerned with the very early, subtle, global, and individual stages of the disease process, whereas conventional medicine tends to intervene at more anatomical and biochemical levels. Depending upon the level at which they operate, different methodologies of both diagnostic and therapeutic type are adopted, which should be fully integrated in the patient's best interests.

7.5.3. Integrated approach and specificity

Nobody today, even on the conventional medicine front, would deny the fact that when treating a disease we have to aim at putting the real situation of the patient as a whole into proper perspective. This precept is undoubtedly accepted theoretically by the advocates of any type of therapeutic approach, whether homeopathic, allopathic, or otherwise, but in practice it is hard to apply to actual cases. Despite the good intentions, the doctor is obliged, in his diagnostic and therapeutic efforts, to split off the disease process from the host body and to concentrate all his or her attention and therapy on the organ, cell or molecule. Though in many cases this will prove immediately effective, in others it fails to resolve the situation and above all to allow implementation of a complete therapy, because it is unable to influence all the levels of imbalance that have led to the disease and modulate its course. To achieve this ideal, almost utopian goal we currently lack both the "diagnostic" and therapeutic means.

In this connection, the route traced by the homeopathic method is suggestive in view of its tendency to consider not only the details, but also the "central core" of the patient's abnormal condition, as it may be perceived by the physician on the basis of the detailed study of the patient's "history", analysis of his or her

type of constitution, attention to neurological and also psychological symptoms, and consideration of physiological peculiarities (tastes and aversions for certain foods, neurovegetative functions, etc.) and of the patient's reactivity to environmental stimuli (heat, cold, meteorological and seasonal changes, and so on).

Homeopathy is a "*probe*" into complex systems. Despite all the limitations related to difficulties in rendering the homeopathic approach objective, it is clear that it entails an attempt to "explore" the patient's medical history at the level of the neuroendocrine system and thus to calibrate some form of therapeutic intervention at this level, too. Homeopathy and homotoxicology regard inflammation as a "symptom" (i.e. as a signal or message) and not as a "disease", and they regard this symptom as the expression of an alteration of the relationship between subject and environment and/or between systems in the same subject. In the light of what we have said about the complexity of living systems, these concepts appear to be of great topical interest, quite apart from the difficulties encountered in rationalizing and perhaps even in demonstrating everything that homeopathy claims.

Homeopathy used with ultra-diluted drugs is thus a tentative approach to the bioenergetic regulation of the human body, utilizing a physical-biochemical interface due to the extreme sensitivity of biological systems to this type of regulation. The strength of the method consists in the fact that it attempts to achieve the maximum possible degree of *specificity* of the exogenous regulatory intervention. As stated earlier, the effective doses will be lower, the more specific the stimulus and the more sensitive the target system. If we admit that information is contained in metamolecular form in the homeopathic remedy, this information may also act in a metamolecular manner in the bioenergetic target system.

How can the maximum specificity of information be achieved, if we know so little about such bioenergetic systems? The answer is implicit in what was outlined in Chapter 6 of this book: *through the application of the law of similars*. This fundamental principle, based, as it is, essentially on the observation of *effects* (i.e. on comparison of the effects of the drug with those of the disease), is in a certain sense independent of any knowledge of the mechanism which causes the effects and thus also applies to the metamolecular level, once we have admitted the existence of the latter.

Homeopathic reasoning is based more on analogy than on inductive thinking. The use of analogy (identification of similarity) is justified on theoretical grounds on the basis of the fact that the various elements of reality are interlinked, because they all derive from the same evolutionary process; in nature, we find the result of a growth of items of information which are always kept "in contact" with one another (cf. fractals). Animals have always lived in contact with vegetable substances and minerals, and it is for this reason that a molecule contained in a flower may be "similar" to molecules contained in the animal, and there may therefore be a transfer of information.

Information is transferred only between similars, or between opposites, or in any event between elements that are capable of interacting as a result of affinity of structure or of vibrational frequencies (harmony, resonance, coherence). Analogical reasoning consists in grasping this basic principle. Reality has grown like a fractal and resembles a hologram: the complex contains the simple form, and the simple form contains the program of the complex.

The "secret" of homeopathy lies in the meticulous gathering of information both in the proving phase and in the homeopathic history-taking phase. This information can come from the hidden depths of the homeostatic regulatory system under investigation, but is still information. In the homeopathic method it is used directly in the therapeutic intervention, trusting in the fact that the body will know how to receive, decode and utilize this informational input for the purposes of restoring the lost equilibrium.

Going over from collecting data to implementing therapy, regardless of the diagnosis in the classic sense, might seem to be a leap in the dark, in which one gives up any attempt to rationalize the pathophysiological picture. In actual fact, this leap in the dark applies only to those who use homeopathy as an alternative to rigorous, scientific clinical reasoning; this alternative was comprehensible once when such reasoning was practically impossible. Today, this is no longer the case: homeopathic thinking can and must integrate with scientific reasoning regarding the known mechanisms of disease, because, as we have seen, the similarity can be rationalized and understood also at more precise and profounder levels than those relating merely to the symptoms.

There is no valid reason for excluding from the gathering of symptoms the execution of laboratory tests and diagnostic imaging; indeed, there are excellent reasons for using them, in view of the fact that any increase in knowledge does nothing but enhance the "image" of the disease and thus facilitates therapeutic decisions. The problem rather is of a practical nature: we should review the classic pathogenetic pictures of the various homeopathic remedies, integrating them with the most up-to-date knowledge. This will involve

repeating large-scale provings in healthy subjects and clinical trials in groups of patients, or the design and conduct of new trials with newly identified compounds.

Another “secret” of homeopathy is that it deals with the human being as a whole, devoting the maximum attention to symptoms of a psychological type and those peculiar to each individual subject (individualization). In this way, it achieves a very substantial measure of specificity, inasmuch as it is now well known that the response to drugs can vary on the basis of the characteristics of the individual user.

If to these considerations we add the fact that we are witnessing a convergence of the homeopathic and the acupuncture approaches (particularly as regards EAV, but also over other by no means marginal aspects, such as biorhythms, the analysis of symptoms, disease etiology, and diet), it will be appreciated that the ability to gather information is gaining in strength also in technological terms. If it were true, as the studies presented above appear to suggest, that the sensitivity of a given patient to a given compound can be detected by measuring the currents travelling along the meridians, we would thus have another key to penetrating the “sanctuary” of biological and pathological information. Gathering information, such as knowing, for instance, whether a certain patient is allergic to or intolerant of a certain compound, or knowing whether a certain drug restores the balance or produces electrical dysequilibrium would be an undeniable step forward from the point of view of diagnosis and therapy.

An interpretation of homeopathy such as that presented here reconciles the “integrated” view, which considers the complexity of the human being in all his or her components, with the “reductionist” view, which considers the single organ, cell, or molecule. In fact, there cannot be a contrast between the whole and the fragment which this whole contains. On this basis, the controversy between homeopathy and allopathy, as if only the latter were “scientific”, actually appears quite anachronistic. As we have seen in other sections of this book (Chapter 6, Sections 2.6 and 2.7), homeopathy and allopathy have different and specific indications, though in many cases they can usefully be combined.