

CHAPTER 1

Introduction to the Theory of Water Memory and General Principles of Water Activation

1.1. Water Structure and the Paradoxes of Water Memory

In the vital activities of any biological object, the most important chemical compound is water. It is difficult to enumerate all the functions of water in biological systems.

It is well known that water is a base of the intracellular liquid. It is the transport medium for the transfer of important chemical elements, forms the necessary states of these elements in the form of atomic and molecular ions, and ensures the normal vital activity of all systems of organism.

Water is the principal element of the very efficient system of thermoregulation and thermostabilization of all warm-blooded organisms. However, until now the mechanisms of the strikingly efficient system of thermostabilization of living organisms have not been clarified.

Intracellular water is the main participant of all radiobiological processes. It is the medium in the bulk of which the primary radiobiological processes of interaction of various types of the ionizing radiation (X-rays, gamma-quanta, fast electrons, heavy ions, and neutrons) with living objects are carried out. Water favors the formation of free-radical complexes which play decisive roles in radiation-induced damages. It is known that such indirect mechanism is responsible for more than 95% of total damages induced by radiation.

Furthermore, water is the basis of a totality of processes which underlie the phenomenon “*hormesis*”, whose essence consists in the positive action of small doses of ionizing radiation on every biological object. These questions are considered comprehensively in our works (Pinchuk and Vysotskii, 2001; Vysotskii *et al.* 2002) and are generalized in the book (Vysotskii, Smirnov and Kornilova, 2005).

The spatial structure of water agrees ideally with the secondary structure of a DNA macromolecule, by guaranteeing the maximally stable existence

of the double helix formed from matching pairs of nucleotides. Moreover, there are weighty arguments that the water of the primary ocean, whose composition was very close to that of the intracellular liquid, became the spatial matrix on which the first macromolecular DNA was synthesized.

At the same time, water is one of the most mysterious chemical compounds. Up to now, there is no unambiguous answer to the question of the spatial structure of water at the supermolecular level. Anomalous properties of water have for a long time become a classical example of the manifestation of characteristics of a nontrivial system. Water is the most universal solvent.

Intense doubts arise about the question on “the water memory”, i.e. whether one can somehow change the properties of pure water (without changing its chemical composition) and preserve these properties for a long time. In the “near-science” and popular literature, a lot of information is available about the phenomenon that a significant change of the characteristics of water occurs under the action of various external factors. Such actions are called the process of activation of water, despite the fact that each experimenter embeds his own interpretation in this notion.

In modern scientific literature, water is considered to be activated if it (1) has undergone the action of a constant or variable electric or magnetic field, (2) is under the direct action of nonionizing SHF emission, (3) is subjected to impact or harmonic mechanical actions, or (4) is passed through heat treatment (with a decrease or increase in temperature) or a phase transformation (in particular, a freezing or a thawing transformation).

Contrary to the above, in mass media, which are far apart from science, water is said to be activated or “charged” if it is directly affected by a man who manifests strong extrasensory characteristics. Whether these methods can really influence the structure of water, or that they most likely act on the psychic state of the witnesses are questions to be solved in the future.

As one more stumbling-block, we mention experiments involving different methods of activation and utilization of water. Such experiments are numerous. They were executed by known scientists and by those who can hardly be referred to as experts or scientists. For the latter, their results were given mostly in the forms of sensational communications in newspapers, on TV, and through the internet recently, rather than in the form of scientific papers. In the majority of cases, it is very difficult or even impossible to estimate the reliability of such communications. As a rule, these sensations usually contain no information about the method of activation, about the methods and statistics of measurements, and very frequently they contradict

the simplest theoretical estimates, saying nothing of more strict theoretical models. At the same time, a more involved and general theory was not developed and does not exist up to now. For this reason, the results of these experiments were often ignored by members of the scientific community, and incomprehensible results were at once and without analysis referred to as wittingly erroneous.

There exist rare communications that some of the changes induced in water during the process of activation can be preserved for a long time (hours or days). Moreover, the mass media sometimes present the information that the activated water in some way possesses unique physicochemical properties and, in this case, can render a significant positive action on vital activities of living organisms and on the course and the treatment of many diseases.

Unfortunately, scientific literature does not include the publications presenting the results of correctly executed systematic studies which demonstrate that activated water does possess particular physical properties and renders positive influence on biological systems. It is practically impossible to encounter such publications in serious journals, because the editorial boards of these journals are strongly prejudiced against such investigations.

We can list a lot of specific reasons for such a situation. However, it is obvious that this is a consequence of a deep-rooted skepticism of the question about “the water memory”. Such skepticism appeared shortly after the very great successes of quantum mechanics at the first half of the 20th century in the study of relatively simple systems such as atoms, simple molecules, ideal gases and perfectly-ordered crystals. The next natural step was the transfer of the principles of the spatial organization of the ideal gas and crystals to real liquids.

At first sight, it seemed that this problem can be solved comparatively simply and rapidly. The model of water was limitedly simplified so that it was identified either with the system of a dense gas or with the ideal dynamic crystal with ordered hydrogen bonds and very great coefficient of diffusion. The duration of relaxation of any perturbations in each of these systems is very short and does not exceed several parts of one nanosecond. In the framework of such an approach, it was natural that any consideration of the long-term water memory was simply irrelevant. Moreover, those who were engaged in this field were labeled, in the best case, as “alchemists” or false scientists.

However, the structure of water turns out to be much more complicated than what was conceived in the original idea. Water has simultaneously the

properties of a gas and a crystal, and its behavior frequently contradicts either of them. The comparatively simple computational methods, which allow one to determine the main characteristics of a crystal based only on the properties of a separate atom or a molecule, turned out to be clearly insufficient for the construction of a complete theory of water. (This problem will be discussed in more details in the following chapter.)

No matter how paradoxical it sounds, a certain contribution to the process of distinctive ignorance of the role of water as one of the main players in living organisms was introduced (and is introduced) by biochemistry and theoretical biology. Of course, on the systematic level, the role of water is always emphasized. But it is implicitly postulated that water plays, in fact, a passive role. Water is considered as a space for the realization of the ion transport, as a medium for removal of wastes from the organism, as a base of thermodynamics, and as the main factor of thermostabilization of organism. Water is considered as a stage, on which the great performance named “Life” is being played. Of course, there is no performance without a stage which gathers all the participants in a single collective by the principle of the unity of place and time, but the role of a stage is always passive.

But, in fact, water is a participant (possibly, a principal one) and an actor of this performance, and it possesses absolutely equal rights with others! Water directly affects all the processes in an organism, and these processes, in turn, influence water, change the properties of water, and are simultaneously subordinated to water. In this case, not only the global action of water, but also the influence of each individual molecule turn out to be important.

We give one characteristic example which confirms this assertion in full measure:

It is well known that the base model of the organization of DNA is the so-called “compressed” form A which corresponds to a maximum of the binding energy of subsequent complementary pairs of nucleotides in the absence of some external medium (in fact, in vacuum). This maximum is determined by the period $R_0 = 2.8 \text{ \AA}$ between subsequent pairs of nucleotides in the double helix of DNA and by the angle of their mutual turn equal to $\theta = 30^\circ$. This configuration was calculated many times, starting from the conception of the existence of two types of interaction in the regions between the successively located pairs.

The first type of interaction is the Coulomb electrostatic interaction of the ions distributed over the surface of a nucleotide. This interaction corresponds in most cases to the mutual repulsion of the pairs of nucleotides.

The second type of interaction is the dispersive van der Waals interaction, which defines the coupling between separate structural elements opposite to nucleotides (in fact, between the atoms distributed over the surface of these nucleotides). This interaction corresponds, as a rule, to the mutual attraction.

On the other hand, it is reliably known (for example, on the basis of the data of numerous X-ray diffraction studies) that only the “stretched” form B, i.e. the centered double helix form of DNA, is realized in the presence of water near DNA. In this form, the stable distance between the mean planes of any pair of nucleotides (i.e. the period of the structure of DNA) is $R_0 = 3.4 \text{ \AA}$, and the angle of the mutual rotation of the pairs of nucleotides $\theta = 36^\circ$.

This fact is sufficiently paradoxical. The matter is that, both in the compressed and stretched forms of DNA, the distances between the separate pairs of nucleotides with regard to the spatial period ($R_0 = 2.8 \text{ \AA}$ or $R_0 = 3.4 \text{ \AA}$) and the efficient “thickness” of each nucleotide (about 1 \AA) turn out to be significantly less (the distance is about $1.8\text{--}2.4 \text{ \AA}$) than the effective size of a water molecule which is equal to 2.76 \AA . Thus, a water molecule cannot be inside the stack of complementary pairs of nucleotides. In such geometric structure, water cannot render a “direct” influence on the character of the interaction of adjacent pairs of nucleotides (on the *stacking* energy) at the expense of, for example, the screening of the field of charges or a significant modification of the dispersive interaction.

The situation looks really strange. Indeed, the effect of an increase of the period of DNA exists, and it is well-known from experiments that this effect is related to water. But no specific numerical analysis of its appearance was actually performed.

The calculations carried out in the work of Vysotsky and Hovorun (2005) showed that the answer to the mechanism of changing the stacking energy can be related to the direct influence of polar water molecules located outside the scope of the space under consideration i.e. between the nucleotides (though in close proximity to this space) on the total energy of the system. These molecules interact simultaneously and directly with different pairs of nucleotides, and create the necessary modification which ensures the turning and displacement of nucleotides from the compressed form to the normal form of DNA.

For successive analysis of such a problem, the calculation of the three-dimensional distribution of the total energy of the system, which included the interaction energy of two nearest pairs of nucleotides and the interaction

energy of these pairs with a water molecule, was carried out. It was then necessary to study the position of the minimum energy as a function of the mutual orientation and distance between the mentioned pairs of nucleotides.

To study the exact dependence of possible positions of water molecules in the region of the double-strand break of DNA, the real geometric arrangement of atoms for the Watson–Crick complementary pairs of nucleotides GC (the number of atoms is 29) or AT (the number of atoms is 27) was used. All calculations were performed for the B-form of DNA, for which the propeller angle (the dihedral angle between the planes of bases) $\theta_p = 2^\circ$, the rotation angle of the helix $\theta = 36^\circ$, and the slope angle to the helix axis $\theta_\gamma = 5.9^\circ$.

The total energy of the system “terminal pairs of nucleotides — a water molecule” consists of

- the interaction energy between the terminal pairs of nucleotides in the region of the double-strand break of a DNA helix;
- the total interaction energy between the atoms of each terminal pair of nucleotides in the region of the double-strand break of the DNA helix with a water molecule which is located in the region (or directly near the region) of the break.

The results of calculations of the potential energy of interactions between two neighboring pairs of nucleotides (curve 1), the interaction between these pairs and one water molecule (curve 2) and, finally, the total interaction (curve 3) are presented in Fig. 1.1.

It is seen from this figure that the presence of a single water molecule, being in the position of a stable minimum near the external of a pair of nucleotides (i.e. near external surface of DNA), shifts the position of the stable equilibrium of this pair from $R = 2.8 \text{ \AA}$, corresponding to a molecule of DNA in form A, to $R \approx 3.2 \text{ \AA}$, which is very close to the characteristic period $R_0 \approx 3.4 \text{ \AA}$ of a macromolecule DNA in form B.

The physical reason for such a deformation of the DNA helix in the presence of a water molecule is related to that, in the scope of the strongly interacting system “a water molecule + a pair of nucleotides”, all its components are revealed as participants with quite equal rights, and the very strained state of DNA is a result of the distinctive compromise between two tendencies:

- on the one hand, the interaction between two pairs of nucleotides at the distance $R \approx 3.3 \text{ \AA}$ corresponds to the appearance of a force

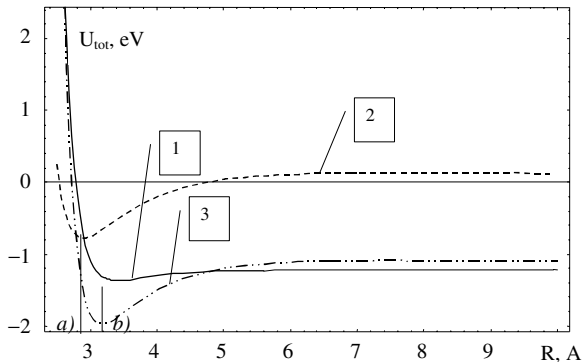


Figure 1.1. Influence of a single water molecule on the structure of DNA. The dependence of the total energy of the system “a water molecule — terminal nucleotides” (curve 3), the total interaction energy between the terminal pairs of nucleotides (curve 2), and the total interaction energy between two neighboring pairs of nucleotides and the water molecule (curve 1) on the distance between nucleotides R . In all the cases, the water molecule is at the point near the external surface of nucleotides which corresponds to the absolute minimum of the energy of its interaction with nucleotides. The points with coordinates $a)$ and $b)$ determine the positions of the minimum of the potential energy in the absence of water and in the presence of one molecule of H_2O .

$F = -dU/dr$ which tends to compress a DNA helix to the period $R_0 \approx 2.8 \text{ \AA}$ (this is a position of the minimum interaction energy of the pairs of nucleotides in vacuum);

- on the other hand, the interaction of a water molecule with the same two pairs of nucleotides causes the appearance of another force which tends to pull a water molecule as far as possible in the region between nucleotides and, hence, separate these pairs and increase the distance between them to $R_0 \approx 3.5 \text{ \AA}$ (this distance corresponds to a minimum of the interaction energy of a water molecule with a pair of nucleotides).

It is seen from the results of calculations that the inclusion of even one water molecule causes a very strong deformation of DNA. This result presents a sufficiently grounded explanation for the physicomolecular mechanism of the deformation of DNA when it comes into contact with water.

It should be noted that taking into account other water molecules which are near the external surface of DNA will allow one to calculate more exactly the structure of the stretched form of DNA.

This example demonstrates the obvious (but, nevertheless, very frequently ignored) argument that water is really an active player, rather than a passive one. One more important conclusion which follows directly from the performed analysis consists in that a molecule of the bound water near the surface of DNA is the integral component of DNA like other atoms which belong to the composition of nucleotides. This result was always perceived as intuitively obvious, but it was not confirmed by the results of direct calculations.

It is noted that whereas the problem concerning the structure and the properties of water was the object of numerous studies, the applied aspects of the influence of activated water on biological systems are presented by a collection of uncoordinated rare results which are frequently in poor agreement between themselves and sometimes mutually contradictory.

Below, we present some data from the literature which characterize changes in the properties of water and the specific features of its action.

For example, the main characteristics of water change after it passes through the region with a constant magnetic field (Klassen, 1973). In particular, if the intensity of this field varies from 1900 to 5700 Oe, the pH of chemically pure water (bidistillate) changes by 5.1–9.1%, and the surface tension changes by 2.2–7.3%. Such magnetic treatment changes the spectrum of infrared absorption of water. In water which passed through a region with a sufficiently strong magnetic field, the efficiency of the processes of dehydration of dissolved diamagnetic ions decreases and, on the other hand, the efficiency of the dehydration of paramagnetic ions increases.

For the same water, its ability to wet surfaces is also significantly changed. In this case, the effect turns out to be somewhat ambiguous: if the surface contains Si, then the wettability grows, and it decreases, as a rule, if Si is absent.

The magnetic treatment of water causes a very significant change in the dissolving rate for many salts. For example, the dissolving rate of magnesium sulfate increases by 120 times under the action of a strong magnetic field, which is realized in the mode of a sharp change in the direction of this field on water.

In a number of works, the derived results testify that a significant change in the refraction index of aqueous solutions of the proteins of blood plasma occurs under the action of a weak microwave emission. The refining experiments showed that the main contribution to this effect was given by a change in the refraction index of water itself.

The enumerated anomalous properties of water which has undergone the action of a magnetic field preserve for many hours and days.

It follows from experiments that such activated water possesses the changed physicochemical properties and, in some cases, can render a specific influence on biological objects (including a beneficial action on the treatment of some diseases).

One more aspect concerning the problem of water memory is associated with the possibility to preserve the information. This is related to dissolved chemical compounds with a great degree of dissolution in water. In fact, such a problem corresponds, by all canons, to classical homeopathy with its fundamental principle of manifold dissolution in water.

Among the works which caused great resonance at that time, we focus on the work (Davenas, 1988) published in the authoritative journal *Nature*. In this work, it was found that water preserves the information of trace amounts of some biologically active substances (i.e. that water was, in fact, chemically activated). This piece of information was not lost after extremely strong dilution, when the molecules of a dissolved substance were almost completely absent in water. This work describes the studies on classical immunology performed by a group of researchers led by the French biochemist J. Benveniste. They studied the specific influence of protein molecules on blood cells which are named basophils. These molecules induce their specific response called degranulation. According to the concepts of biochemistry, the greater the concentration of such proteins, the higher the rate of degranulation. Also, the rate decreases as the concentration decreases. Contrary to this idea, it was found in experiments that the clearly pronounced effect of degranulation of basophils was observed even at the extremely great dilution of the solution of protein molecules (antipolyglobulins), where their relative concentration was at most 10^{-30} (which corresponds to only one molecule per 70 liters of water!). Since the volume of a cuvette, where these studies were carried out, was much less than 70 liters, this means that none of protein molecules was present in the volume of water after the manifold dilution.

The experiments which were executed in this work demonstrated that this type of information can be stored for a long time in unperturbed water at sufficiently low temperatures, but it is efficiently “erased” under classical actions such as ultrasound, strong heating, or the phase transition such as the freezing of water and the thawing of ice.

We note that the medical aspect of the action of activated water is poorly studied, though this action has been confirmed by many experiments.

As an example of the influence of activated water on the vital activity of simplest microorganisms, we point out the results of studies performed on the Faculty of Biology of Lomonosov Moscow State University (these results can be found in the unpublished doctoral dissertation by Zenin, 1999).

The activation of water was realized by subjecting it to a variable magnetic field created by a standard magnetic mixer between 7 min and 15 min. Such water undergoes a number of physicochemical changes (including a change of its conductivity). In particular, the preliminary studies showed that, for distilled water undergone processing for 7 min, its conductivity increased at least by 10–15 times. The growth of the conductivity obeyed an almost linear law. After the cessation of the action of the variable magnetic field, a slow relaxation of the conductivity which decreases to the initial value was observed for 20–25 min. The other situation occurred at a more prolonged action. At the initial stage (during the action of a variable magnetic field), an analogous increase of the conductivity of water was observed. However, after the cessation of the action of the magnetic field, the effect of a spontaneous additional increase of the conductivity of water by 2.5–3 times for 15–20 min was observed instead of its decrease. Such result shows that the system responsible for water memory is characterized by the threshold time interval of irreducible activation from 7 till 15 min.

This activated water was used immediately after the completion of the activation to study the action on *Spirostoma*. If water was subjected to the short-term subthreshold action of a magnetic field, the motive activity of infusoria was inhibited for a short time interval of 30–40 min. If water has undergone the long-term (above-threshold) activation, *spirostoma* were irreversibly paralyzed with the full suppression of all signs of activity.

There are many such facts demonstrating the unusual behavior of water subjected to certain physical actions. Concluding the brief and incomplete analysis, we mention the following circumstances:

On the one hand, the popular literature and the mass media present a lot of information (frequently, with obvious advertising characteristics) on the beneficial effect of “charged” and activated water. Such water was advertised very frequently as a distinctive panacea for any diseases without any substantiation. It is natural that the scientific value of such communications is close to zero.

On the other hand, we failed to find the description of at least one cycle of studies which are executed with sufficient completeness by the commonly-used rules of scientific studies and which present the reliable

results concerning not only the action of activated water of the same type on biological objects, but also the properties of this water. We received impression that the study of all specific features of the influence of activated water on biological systems turns out to be outside the field of interests of classical biology.

It is necessary to note that we had no preliminary “barrier-type separation”, at which all similar results would be rejected *a priori* without analysis. We think that water, being life’s cradle, renders very strong influence on the character of vital activity. Many genetic and somatic diseases, like problems in the mechanisms of division of cells, reproduction, and mutations, are integrally related to water.

Prior to the detailed investigation of these questions, we consider the specific features of the structure and the problem of the memory of ordinary and activated water in more details.

1.2. The Clathrate Model and a Water Memory Cell

There exists a great number of various theories and models explaining the structure and properties of water. In each of them, the basic position is the idea of hydrogen bonds as the main factor defining the formation of structurized agglomerates. For this reason, water is a cooperative system, and it contains the chain formations of hydrogen bonds.

Water possesses a number of unique properties, among which a particular place is occupied by its long-term “memory”. Numerous experiments, some of which were presented above, have confirmed the existence of water memory, which is activated under the action of some physical fields (for example, a magnetic field, impact mechanical action, sharp change in the temperature or pressure) and can store the information about this action for many hours and days.

The above-presented facts painted one visible side of the problem. Just this side arouses the greatest interest, but simultaneously raises the greatest number of objections. The other side of the problem is based on the explanation of these effects and on the clarification of their mechanisms. We would consider it in more details.

At first sight, it seems that water, as a specific physicomolecular object, cannot have long-term memory. This follows from the following simple evaluations:

For a long time, the continual (quasicrystalline) model of water was dominant. In the framework of this model, the spatial structure of the

potential energy for each of the molecules H_2O is the almost periodic three-dimensional system of potential wells and barriers. This relief is a result of the self-consistent motion of all water molecules which combines two independent processes: the oscillatory motion in each of the potential wells and a random (fluctuation-related) hop to the neighboring well. The mean frequency of oscillations in potential wells is approximately the same as the Debye frequency in solids ($\omega_D \approx 10^{13} \text{ s}^{-1}$). The mean duration of a hop to the neighboring potential well $\tau_0 \approx 10^{-13} \text{ s}$. The mean duration of the stay in a well,

$$\langle \tau \rangle = \tau_0 e^{\Delta W/k_B T} \approx 10^{-9} - 10^{-10} \text{ s}, \quad (1.1)$$

is determined by the temperature T of water and the activation energy, $\Delta W \approx 0.2 \text{ eV}$, of the process of diffusion (by the height of a barrier between the neighboring wells). Staying in the framework of this model, it is easy to conclude that the water memory must be preserved not longer than the value of $\langle \tau \rangle$ which is by many orders less than the values given by numerous experiments.

The continuously increasing number of reliable experiments indicates that the continual model describes inadequately the structure of water.

The presence of a spatial structure in the bulk of water was first proved by Bernal in 1933.

The calculations on the basis of quantum chemistry showed that water molecules participate in the formation of molecular ensembles and can form various types of associated molecules: hydrol H_2O , dihydrol $(\text{H}_2\text{O})_2$, trihydrol $(\text{H}_2\text{O})_3$, etc. Further studies showed that much greater associations (clusters) of water molecules can be formed in water, the structure of which resembles small pieces of ice. As a rule, these clusters are unstable and spontaneously disappear. The dynamics of such associations underlies the cluster model of water (Nemethy, 1962). In the framework of such a model, one may consider that water is a two-phase system — a crystalline liquid with the intense processes of crystal-forming and strong intermolecular bonds (hydrogen bridges), with the ability to form agglomerates of hundreds of molecules and generate the infinite number of forms of the liquid-crystalline phase in water which is named a complex lattice-like structure. Such a structure is characterized by the great number of eigenfrequencies.

The more detailed studies (for example, Samoilov, 1957) showed that the so-called “clathrate” model is most close to the reality. In the final form, this model was developed by Pauling (1959). The Pauling clathrate model is

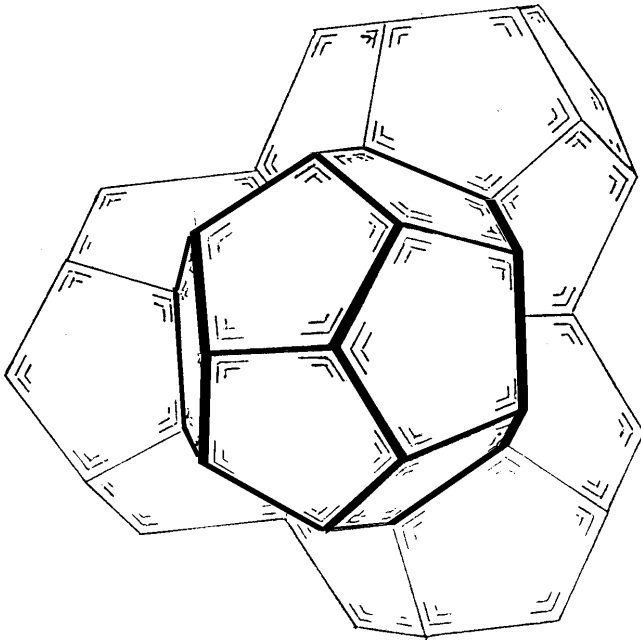


Figure 1.2. System of clathrate hydrates in water.

based on the idea that the union of atoms of oxygen and hydrogen is able to create spatial flexible tetrahedral frames. The spatial structure of the frame is given in Fig. 1.2.

The formation of tetrahedral frame is promoted by the circumstance that the natural spatial angle between the OH-bonds in a free molecule of water H_2O is equal to 104.5° , which is sufficiently close to the exact value of the tetrahedral angle of 108° . For the additional bending of this bond by an angle of 3.5° , a small energy is required, and the very presence of an additional bending significantly enhances the stiffness of the crystalline frame (a similar situation occurs, for example, in such purely structural element as a prestressed reinforced concrete).

At nodes of the crystalline frame, there are very large (on the scale of a water molecule) microcavities (microvoids) with rigid atomic walls. The main elements of this structure are regular polyhedrons i.e. dodecahedrons coupled with one another. Such systems are called “clathrate hydrates”. This frame structure is held by hydrogen bonds. They firmly fasten the system of pentagonal dodecahedral polyhedrons of ions of oxygen and hydrogen

which form the walls of microcavities. Each polyhedron can be characterized by an inscribed sphere with the radius $R_c \approx 2.6 \text{ \AA}$. Each polyhedron has 12 pentagonal faces, 30 edges joining these faces, and 20 vertices. At each vertex, three edges come together. At the vertices of each polyhedron, 20 molecules of H_2O are situated, and each molecule of H_2O has three hydrogen bonds. By the data in Zenin (1999), three polyhedrons can be joined in stable associates containing 57 water molecules. From these 57 molecules, 17 ones have completely saturated hydrogen bonds and form a tetrahedral hydrophobic central frame. Moreover, the surface of each of four dodecahedrons contains 10 centers of the formation of a hydrogen bond (O-H or O).

Outside of this frame, there are quasifree molecules of “ordinary” isotropic water, whose properties and structure approximately correspond to the continual model. Microcavities of the frame are joined with the external space by windows of about 2.5 \AA in diameter, which is not much less than the width of a water molecule ($2R \approx 2.76 \text{ \AA}$). Finally, each of the microcavities is separated from the “external” amorphous quasifree water by a ring-like potential barrier of about $\Delta R \approx 0.13 \text{ \AA}$ in width which borders a window. The relative amount of molecules of “frame” water at room temperature is 20–30% and increases as the temperature decreases. In the volume of a microcavity, one of the molecules of H_2O , CH_4 , O_2 , or N_2 , for example, can be freely arranged.

Due to the presence of a strong and symmetric (relative to the centers of microcavities) electrostatic field, there exists a certain ban on the formation of hydrogen bonds of water molecules in microcavities with their walls. In this case, there occurs such nontrivial phenomenon as the repulsion of free water molecules from the walls of the frame formed also of water molecules (i.e. water molecules in the volume of water become hydrophobic)! The mean density of the clathrate frame (without the filling by water molecules) is 0.80 g/cm^3 , i.e. microcavities occupy 20% of the entire volume of the structurized frame of water. If the microcavities are filled by water molecules, then the density of water is close to 1 g/cm^3 .

The results of direct measurements (Zenin, 1999) showed that the optical properties of structurized and amorphous water at the same temperature differ very strongly. In particular, the difference of the refractive indices of the clathrate frame and amorphous water reaches 4–5% in some cases, which testifies to the spatial ordering of the clathrate frame.

The Pauling clathrate model explains very well all the properties of water (including its anomalous compressibility). The structure of DNA perfectly

corresponds to the spatial structure of such frame water. In this case, every macromolecule of DNA puts water in order at the distance to 300–500 Å from its surface. The possibility to join the Pauling clathrate model with the cluster model was considered in many works. In this case, the separate elements of clathrate frames can be joined from time to time by hydrogen bonds and form groups possessing an ordered structure (i.e. clusters). Since there exists a very strong interconnection between the neighboring hydrogen bonds, the appearance and elimination of hydrogen bonds occur in a correlated manner and are synchronized in time. Such a character of the bond allows us to suppose that the “flickering clusters” arise and disappear in water. The lifetime of clusters is of the order of 10^{-10} s, i.e. of the order of 1000 molecular oscillations.

The considered specific features of the bulk water structure indicate that water molecules are always distributed between two systems weakly coupled with each other: the quasiamorphous nonstructured water and the quasicrystalline structured system of clathrate hydrates. During the external action on water (i.e. on the activation of water), there occurs a significant change of its structure and parameters. In view of the scale and mechanism of activation, two different hierarchical levels of organization of the water structure (a macrolevel and a microlevel) exist.

The first hierarchical level of the water structure (the macrolevel of the structure) corresponds to the global spatial structure of water and defines the form and the position of its spatial frame. This level is characterized by the presence of the system of clathrate hydrates which form stable dodecahedral polyhedrons of ions of oxygen and hydrogen. Inside the volume of each of these polyhedrons, there exist the empty microcavities with rigid hydrophobic walls. The dodecahedral polyhedrons with the help of stable hydrogen bonds are joined in binary, triple, and more complicated associates which can be further combined in very large associates (macroclusters). The space between macroclusters is filled with the quasiamorphous water.

Thus, the macrolevel of the structural organization of water corresponds to the equilibrium distribution between the phase of amorphous water and the phase of water, represented as a system of macroclusters with a complicated hierarchy. Under the action of the external factors, this distribution can be changed. For example, the volume of macroclusters increases with decrease in temperature, whereas the volume of quasiamorphous water decreases. As the temperature grows, the volumes of macroclusters decrease, and, in addition, each macrocluster can be divided into

several smaller parts. It is natural that the volume of quasiamorphous water increases in this case. The same changes can occur under other types of action, e.g. under the action of ultrasound on the aqueous medium. Due to the strong dependence on external actions, the macrolevel of water structure has no sufficient efficiency in order to organize a water memory system that is stable to the external destructive actions. At the same time, it is obvious that, in the absence of very strong destructive actions, the process of recording of the information in the form of the system of regularly-joined clathrate cells is quite possible. Simply saying, separate polyhedrons of the clathrate frame can be combined by several alternative means. In this case, of importance is that the realization of a certain orientation of a specific pair of polyhedrons leads automatically so that the subsequent polyhedrons will be joined to this “bare” associate in exactly the same way, which induces the appearance of ordered macroclusters. Such a system has obvious long-range order, which can explain the possibility of a global structurization of great volumes of water. This question was sufficiently considered in Zenin’s work (1999).

The second hierarchical level of the water structure (microlevel) corresponds to the processes of motion and distribution of separate molecules of H_2O between microcavities of the three-dimensional clathrate frame of water and the quasiamorphous nonstructurized water. This microlevel defines the nonstationary evolution of H_2O molecules. The process of evolution is determined by two possible directions: molecules can leave the volume of quasiamorphous water, enter into the volume of these microcavities, and be there in the hydrophobic form for a long time or, on the contrary, can pass from microcavities into the volume of the quasiamorphous water.

It is quite obvious that the microlevel of the water structure is distinguished by a much greater stability relative to the action of external destructive factors than the macrolevel. Under all external transformations of the clathrate frame which are characteristic of the macrolevel, hydrophobic H_2O molecules remain in the stable state in the volume of microcavities. Such a stability makes the microlevel of water structure to be an efficient object for the organization of a water memory system. Earlier, nobody has considered such a memory system in detail.

We now show how the presence of the clathrate frame of water can lead to the formation of the long-term memory in water and to the possibility of recording and using the information (Vysotskii and Kornilova, 2004; Vysotskii, 2005).

Consider the initial water which is in the state of thermodynamic equilibrium and is characterized by the definite temperature T . This state corresponds to the maximum of the entropy. Such water can be produced as a result of the long-term boiling and the slow cooling or a very long standing. In this case, the number of microcavities in the system of clathrate hydrates which are filled by water corresponds to the Boltzmann distribution with regard for the statistical weights of the states of H_2O molecules in microcavities and in amorphous water. This is an equilibrium water or an ordinary one.

In the frame, 18% of microcavities are filled by H_2O molecules at a temperature of 4°C , 38% at the normal temperature of a man (36.6°C), and about 50% at 55°C .

Such a law of distribution is related to several circumstances:

- the Boltzmann distribution at the given temperature,
- the degeneration multiplicity of the initial and final states of a H_2O molecules in the composition of amorphous water near an entry window to the volume of a microcavity and in the volume of this microcavity, and
- the ratio between the volume of all the amorphous water and the volume of the clathrate frame.

All three quantities vary with changes in the temperature, which hampers the execution of an exact calculation of the dynamics of the population of microcavities. At the same time, it is obvious that the binding energy of water molecules is close to zero in the volume of clathrate microcavities (due to the hydrophobic character of the interaction with walls), and the state of a H_2O molecule in the bulk of quasiamorphous water is determined by the depth of the potential well conditioned by the interaction with other water molecules. The depth of this well corresponds to the energy of activation $\Delta W \approx 0.2 \text{ eV}$ under the diffusion, which in fact decreases the energy level of a H_2O molecule relative to that of the same molecule in the clathrate frame by ΔW . Based on this consideration, it becomes obvious that the necessary energies of activation for the entry to a microcavity, ΔE_M , and for the output from it, $\Delta E_M - \Delta W$, will be different (Fig. 1.3).

According to this fact, the time for an “excess” water molecule to be present in a microcavity and the time of existence of an “excess” vacancy in an empty microcavity will also be different.

Upon the breaking of thermodynamic equilibrium, the H_2O molecules are redistributed between amorphous water and microcavities to a new equilibrium state. We now show that the spontaneous transition between these

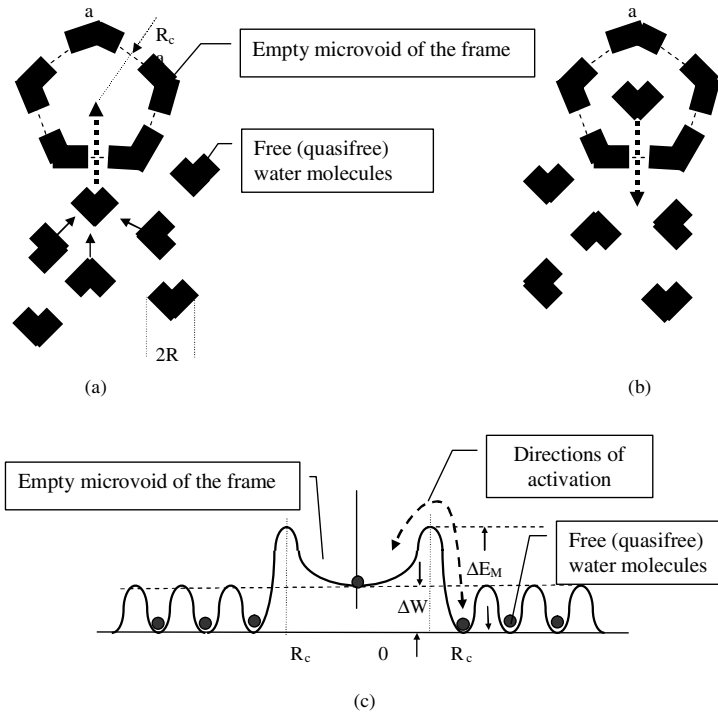


Figure 1.3. Process of (a) thermostimulated activation and (b) deactivation of microvoids of the clathrate frame of water under the increase or decrease of temperature; (c) structure of the potential energy of molecules of amorphous and bound water in the microvoid volume and near its boundary.

states is strongly inhibited due to the very small probability of the tunneling of H_2O molecules through “narrow” windows, and the duration of existence of each state turns out to be very great. Let us determine the duration of relaxation under such a redistribution.

Such a relaxation corresponds to the transition of water molecules in two possible directions: (a) from the state of amorphous water into the volume of microcavities (if the initial amount of water molecules in microcavities was less than a value conditioned by the Boltzmann distribution, which can happen under fast heating of the whole water); and (b) from the state of “excess” water in microcavities into amorphous water (if the amount of water molecules in microcavities was greater than the equilibrium value, which corresponds, for example, to the fast cooling of the whole water).

The process of relaxation of each of these transitions depends on the thermodynamic probability

$$W = e^{-\Delta E_M/k_B T} \quad (1.2)$$

for one of the water molecules to get the energy ΔE_M as a result of many random interactions with other molecules. This energy should be sufficient for a short-term deformation of a water molecule (associated with the increase of the interaction energy between a proton and the ion of oxygen) resulting in the short-term decrease of its size to that of the window of a microcavity and, respectively, the entry of this molecule inside the microcavity.

Since the frequency of collisions of any of the water molecules with the surface of any structural object in water is equal to the frequency of oscillations of molecules near a local equilibrium position $\omega_D \approx 1/\tau_0 \approx 10^{13}$ s, the total probability of capture of a molecule by an empty microcavity per unit time is $F = W/\tau_0$. This formula allows us to determine the average duration of existence of a nonequilibrium (empty) state of a microcavity in the volume of the spatial tetrahedral frame of water (the duration of relaxation of a vacancy in microcavities):

$$T_{1W} = 1/F_1 = \tau_0 e^{\Delta E_M/k_B T}. \quad (1.3)$$

It is obvious that this duration will determine the duration of existence of the water memory on the filling of this microcavity (for example, under the heating of water).

For the determination of the duration of relaxation [Eq. (1.3)], it is necessary to find the quantity ΔE_M which characterizes the height of the potential barrier separating the amorphous water from the empty space in a clathrate. To this end, it is necessary to consider the process of deformation of a water molecule in more details.

The vibrational motion of a proton in a H₂O molecule in the direction perpendicular to the bond line OH corresponds to a harmonic oscillator (Fig. 1.4).

The potential energy corresponding to a displacement of the hydrogen ion by a value r relative to the equilibrium position can be written in the form of the energy of a harmonic oscillator

$$V(r) = \frac{M_H \omega_H^2 r^2}{2}. \quad (1.4)$$

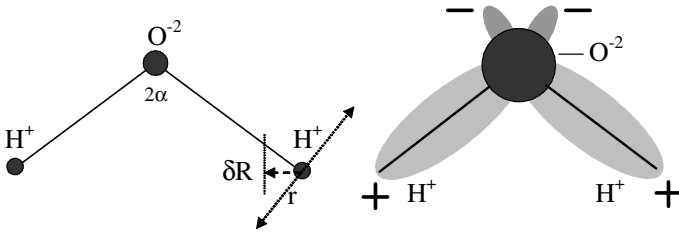


Figure 1.4. Normal oscillations of the proton in a water molecule. Two arrows directed oppositely show the direction of a normal oscillation of the proton.

Here, M_H is the reduced mass of a hydrogen atom, and $\omega_H \approx 3 \cdot 10^{14} \text{ s}^{-1}$ is the frequency of normal oscillations of a proton in a water molecule in the direction perpendicular to the bond line OH (Zatsepina, 1999).

With regard for the fact that the angle between the bond lines of protons with the nucleus of oxygen $2\alpha \approx 104^\circ 27' \approx 104.5^\circ$, we find that, in order to deform the external size of a water molecule by a value $\delta R \approx 0.26 \text{ \AA}$ sufficient for the passage of a molecule into a microcavity, the deformation energy

$$V(\delta R) = \frac{M_H \omega_H^2 (\delta R)^2}{2 \cos^2 \alpha} \approx 1.1 \text{ eV} \quad (1.5)$$

is required. This value determines the threshold energy $\Delta E_M = V(\delta R)$ defining the process of relaxation of water. This threshold exceeds strongly the thermal energy of water molecules equal to $k_B T \approx 0.025 \text{ eV}$ at room temperature. It is seen that the duration of relaxation T_{1W} depends very strongly on the threshold value of the deformation energy of a water molecule ΔE_M and its temperature T . A great value of ΔE_M leads to a small probability to overcome the barrier in the region of the input window of a microcavity. Finally, the probability of spontaneous deactivation of water is very small, which corresponds to a very great time interval of the storage of the information.

We now execute some numerical evaluations. At a temperature of water $T = 293 \text{ K}$ (20°C), the duration of relaxation (the duration of existence of “the water memory”) $T_{1W} \approx 10$ days. As the temperature of water increases or decreases, the duration of relaxation sharply decreases or increases, respectively (see Table 1.1).

For the alternative direction of the relaxation (the transition of a water molecule from the volume of a microcavity into the volume of amorphous water), the duration of relaxation T_{2W} is also determined by a relation

Table 1.1. Dependence of the duration of relaxation of water (the duration of “the water memory”) on its temperature.

T, °C	1	10	20	30	36.6	40	50	60	70	90
T_{1W}	300 days	49 days	10 days	58 h	24 h	15 h	4.4 h	1.3 h	27 min	3 min
T_{2W}	30 min	14 min	4 min	1.5 min	45 s	30 s	12 s	4 s	1.5 s	0.3 s

[Eq. (1.3)], in which the energy of activation is changed ($\Delta E_M - \Delta W \approx 0.9$ eV instead of $\Delta E_M \approx 1.1$ eV). In addition, it is necessary to take into account the following: because the internal size of microcavities exceeds significantly that of the potential well for each molecule in the volume of quasiamorphous water, the effective frequency of collisions of a water molecule with walls in microcavities $\omega_D \approx 1/\tau_0$ will be less (and the period τ_0 , respectively, will be greater) than that in the volume of water. The results of calculations of the duration of relaxation T_{2W} on the reverse transition of H₂O molecules from the volume of microcavities into the quasiamorphous water are presented in Table 1.1.

We note that, in order to calculate the quantities T_{1W} and T_{2W} , it is necessary to know the exact values of the activation energy and the height $V(\delta R)$ of the potential barrier [Eq. (1.5)] regulating the entry into microcavities of the clathrate frame.

We determined these parameters based on the model calculations. The main error can be related to the approximate value, $\delta R \approx 0.26$ Å, of the width of the potential barrier bordering a window being the input to the volume of microcavities in the clathrate. Since δR is present in the exponential component defining the duration of relaxation [Eq. (1.3)] of the nonequilibrium population of quantum states in the volume of microcavities, even small changes in $V(\delta R)$ can very significantly influence both the durations of relaxation. Upon correction of these parameters, the corresponding values of T_{1W} and T_{2W} can be significantly changed.

While varying a value of ΔE_M by $\pm 5\%$ relative to the above-given value of $\Delta E_M \approx 1.1$ eV, the calculated duration of “the water memory” is changed by several orders. These data are presented in Table 1.2.

The obtained values of T_{1W} and T_{2W} correspond to the relaxation of water from the nonequilibrium state to an equilibrium one corresponding to its temperature.

We note that such activated water has other electromagnetic and mechanical properties. Because part of water molecules can be isolated

Table 1.2. Dependence of the duration of relaxation of water on temperature for various values of the height of the potential barrier at the input to the volume of microcavities of the clathrate frame. The quantities $T_{1,2W}$ (5%) and $T_{1,2W}$ (-5%) correspond to the durations of relaxation on the increase or decrease of the height barrier by $\pm 5\%$.

T, °C	1	10	20	30	36.6	40	50	60	70	90
T_{1W} (5%)	7.2 years	550 days	160 days	23 days	9 days	5.5 days	35 h	10 h	3 h	20 min
T_{1W} (-5%)	24 days	5.7 days	31 h	8 h	3.4 h	2.2 h	45 min	12 min	4 min	36 s
T_{2W} (5%)	8 h	2.2 min	34 min	10 min	4.5 min	3.1 min	1 min	22 s	8.5 s	1.5 s
T_{1W} (-5%)	10 min	3.2 min	57 s	18.5 s	9 s	6.4 s	2.4 s	0.9 s	0.4 s	0.07 s

in the volume of clathrate microcavities, the coefficient of absorption of water in the region of frequencies of the microwave range can be significantly changed. This effect is related to the presence of saturated hydrogen bonds in the condensed water and their absence for quasifree H_2O molecules localized in microcavities. In a certain sense, the totality of water molecules in various microcavities is analogous to water vapor, of which each molecule is positioned in its own potential well. We recall that just such an effect of the growth of the coefficient of absorption of water vapor in the microwave range was discovered in Carion's work (1978) devoted to the study of the difference of the absorptions of water and vapor.

If this process is analyzed from the viewpoint of the theory of information, then the formation of a stable nonequilibrium distribution of the population of various clathrate microcavities can be considered by the process of recording of the information in the volume of water. Such water can be named as activated.

The very great duration of relaxation T_{1W} allows us to consider water as a two-level (two-band, to be more exact) bistable system with the great lifetime in each of two states. Such a system allows one to realize the recording and storage of the information (in the form of the ratio of the numbers of filled and unfilled microcavities) and to efficiently utilize this information at the expense of a change in the properties of water on the transition of a great number of H_2O molecules and other atoms, molecules, and ions dissolved in water from the state of amorphous water into the volume of closed microcavities and *vice versa* (Fig. 1.3).

Though the duration of inverse relaxation T_{2W} on the output of water molecules from the volume of microcavities turns out significantly less than the duration of direct relaxation on the input into these microcavities, it exceeds, in any case by many orders, the typical duration of relaxation [Eq. (1.1)] $\langle \tau \rangle \approx 10^{-9} - 10^{-10}$ s owing to the fluctuations of a hydrogen bond in the volume of amorphous water.

There exists one more circumstance which can lead to a sharp increase of the duration of the water memory. It is related to the possibility to populate the microcavities by molecules other than H_2O .

As known, water is a weak electrolyte, and the probability of the equilibrium thermal fluctuation-related dissociation



is always nonzero. The equilibrium relative concentration η_{H^+} of the ions of hydrogen is determined by the hydrogen index $\text{pH} = -\lg \eta_{\text{H}^+}$. In a

normal (neutral) distilled water at room temperature, $\text{pH} \approx 7$, which corresponds to $\eta_{\text{H}^+} \approx 10^{-7}$, and the total concentration of ions of each sign $n_{\text{H}^+} = n_{\text{OH}^-} \approx 6 \cdot 10^{15} \text{ cm}^{-3}$.

On the heating of water to the boiling temperature 100°C , pH decreases almost by $\delta(\text{pH}) \approx 1$. In this case, the values of $n_{\text{H}^+} = n_{\text{OH}^-}$ grow approximately by one order in magnitude.

After a number of transformations (including the neutralization of the ions H^+ and OH^- , their decay, and the subsequent formation of a number of molecular products), the equilibrium distribution of main products of thermolysis (H , H_2 , OH , and H_2O_2) is formed in water. The typical ratios of the relative concentrations of these products are as follows:

$$\eta_{\text{OH}}/\eta_{\text{H}} \approx 4.3, \quad \eta_{\text{H}_2\text{O}_2}/\eta_{\text{H}} \approx 1.25, \quad \eta_{\text{H}_2}/\eta_{\text{H}} \approx 0.75. \quad (1.7)$$

Thus, every cm^3 of water at room temperature contains about 3×10^{-15} to 6×10^{-15} atoms and molecules of H , H_2 , OH , and H_2O_2 . Molecules and atoms of H , H_2 , and OH have sizes significantly less than those of water molecules, and can easily enter into and leave the volume of microcavities in the volume of the clathrate frame. For this reason, such molecules and atoms by themselves cannot be carriers of the information.

The situation will be changed significantly, if the volume of a microcavity can contain simultaneously two particles which can form stable molecules of two types:



We note that the probability of reactions of the second type [Eq. (1.8)] is significantly greater. This is conditioned by a larger concentration, η_{OH} , of OH molecules as compared to η_{H} of atoms H .

The size of a H_2O_2 molecule is greater than that of a molecule H_2O by 9%. This implies that this molecule must be deformed by $\delta R \approx 0.5 \text{ \AA}$ in order to leave a microcavity. By assuming that the frequency of normal oscillations of a proton, ω_{H} , in a H_2O_2 molecule coincides with the analogous frequency of oscillations of a proton in a water molecule, we can find the threshold energy of the deformation $V(\delta R) \approx 4 \text{ eV}$ from formula (1.5).

This value determines the energy $\Delta E_M = V(\delta R)$ related to the process of relaxation of molecules of hydrogen peroxide in water. A molecule of H_2O_2 , which is positioned in a microcavity as a result of reactions, cannot leave it and will be “locked” there for a long time. This time exceeds the

duration of relaxation of water molecules presented in Tables 1.1 and 1.2 by many orders.

We also notice that the activation of water can be realized in various ways, e.g. the process of heating or cooling, as well as magnetic fields or ultrasound.

Such periodic coherent actions can stimulate the formation of quastable clusters, each of which joins several mutually ordered clathrate frames. In such a system, the behavior of isolated water molecules in periodically positioned microcavities is similar to the motion of hydrogen in palladium, where a very high degree of saturation of the lattice is ensured. Periodic actions can also affect the parameters of the clathrate frame of water by changing, for example, the transparence of the potential barrier in the windows of microcavities (it is the problem of tunneling of a H₂O molecule through a nonstationary barrier). In addition, a strong periodic magnetic field can stimulate transitions between the energy levels which characterize the state of H₂O molecules in microcavities and in amorphous water (for example, at the expense of multiphotonic nonlinear processes upon interaction with magnetic moments), which leads to the nonequilibrium population of water molecules in microcavities and corresponds to the activation of water.

Such external action can induce nonequilibrium population of microcavities which cannot be attained by changing the temperature. A similar activation of water can also be reached by uniform compression.

On the basis of such a system of long-term memory, we can interpret many effects leading to the activation and manifestation of anomalous properties of water. In conclusion, we note that the considered phenomena refer to pure water and do not concern the influence of dissolved admixtures (including ions and microparticles of Fe), the very presence of which can induce other effects (for example, in the presence of an external constant magnetic field).

The process of spontaneous and decaying luminescence of water is an indirect confirmation of the fact that the activation of water can be related to a change in the population of microcavities in the clathrate frame and the transition of water molecules from the bound state in the volume of microcavities in amorphous water. This effect was observed many times by many researchers. The reason of such luminescence can be related to the release of local activation energy for a water molecule after its passage of the potential barrier regulating the input or output from microcavities in the clathrate frame. This excessive energy can be directly lighted up after

the completion of such overbarrier transition or can stimulate a number of physicochemical transformations leading to luminescence (i.e. can be its catalyst).

For example, Dr. Voeikov of Lomonosov Moscow State University observed the effect of luminescence using methods of chemiluminescent analysis with addition of salts of bivalent iron and luminol as a fluorophor in water. In particular, such decaying luminescence was observed in artesian water and in water which was in a closed bottle for a sufficiently long time. It is of interest to note that the temporal dependence of the intensity of luminescence depended significantly on the bottle material (glass, ceramic, or plastic). The duration of existence of such luminescence at room temperature was 5–7 days, which well agrees with the data presented in Tables 1.1 and 1.2. In water which was subjected to a preliminary heating to a high temperature and then to a gradual long-term cooling, luminescence was not registered. Luminescence was also not observed in water which was stored for a long time at a constant temperature.

Let us consider some of the experiments on activation of water (Gapochka, 1994) which indirectly confirm, in our opinion, the considered clathrate mechanism of water memory. In these experiments, the influence of a sufficiently powerful microwave emission on water was studied. The experiments were carried out with the use of several modes of action which differed by the frequency, power, type of modulation, and duration of action.

The differential spectra of the optical density of water preliminarily undergone the SHF irradiation were studied in the range $\lambda = 190\text{--}900\text{ nm}$ on a spectrophotometer "Hitachi 557". It was found that the SHF irradiation did not lead to any considerable change in the optical density in the range $\lambda = 350\text{--}900\text{ nm}$, but gave rise to its significant increase in the range $\lambda = 190\text{--}350\text{ nm}$.

In Fig. 1.5, we show a change in the optical density of distilled and bidistilled water irradiated by a sequence of powerful pulses of the SHF emission relative to the density of analogous unirradiated distilled water. For activation, a cuvette with water was positioned in a waveguide connected with a SHF generator. The parameters of emission are as follows: the emission frequency ω is 2.71 GHz; the power, $\sim 800\text{ kW}$; the duration of pulses, $\sim 1\ \mu\text{s}$; the repetition frequency of pulses, $\sim 230\text{ Hz}$; the total time of irradiation, $\sim 5\text{ s}$.

The measurements were carried out in 24 h after the action of the SHF emission on water. It was found that the SHF irradiation induces no

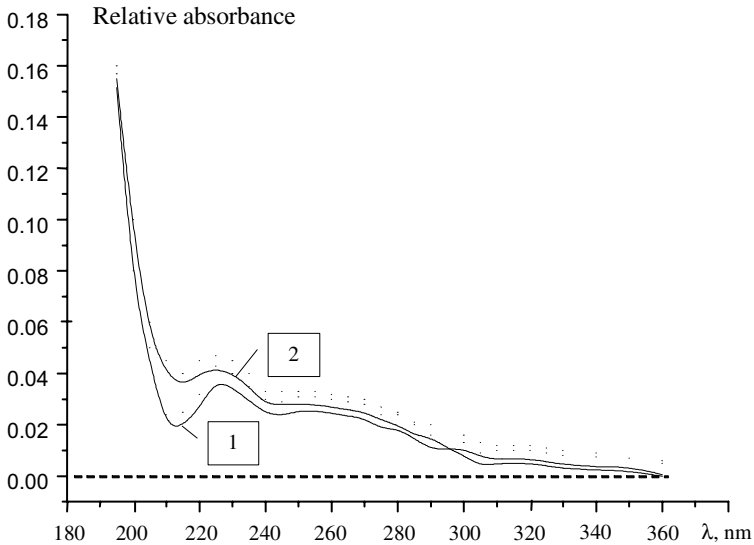


Figure 1.5. Change of the optical density of water of different types irradiated by powerful pulse SHF emission: 1 — distilled water, 2 — bidistilled water.

considerable changes in the optical density in the range 350–900 nm, but leads to its significant increase in the range $\lambda = 190\text{--}350$ nm. It is seen from Fig. 1.5 that the changes are more significant in bidistilled water on the activation than in distilled water. This testifies that the effect of activation is related namely to water, rather than to dissolved salts. For both types of water, two peaks of the absorption at $\lambda \approx 225$ nm and $\lambda \approx 255$ nm are clearly seen. In addition, we see a very great additional increase in the absorption at $\lambda \approx 190$ nm characteristic of any water.

In Fig. 1.6, we present the results characterizing the dependence of the optical density of the identical distilled water on the frequency of the SHF emission. In this case, a generator of continuous emission was used. Its parameters are as follows: the emission frequencies $\omega = 40.00$ GHz, 45.55 GHz, and 53.55 GHz; the power = -10 mW; the duration of irradiation = -20 min. The measurements of the parameters of water were executed in 24 h after the SHF emission.

It is seen from the figure that a very significant change in the optical characteristics of activated water occurs also under the action of a comparatively low-intensity (but continuous) emission. This testifies that the

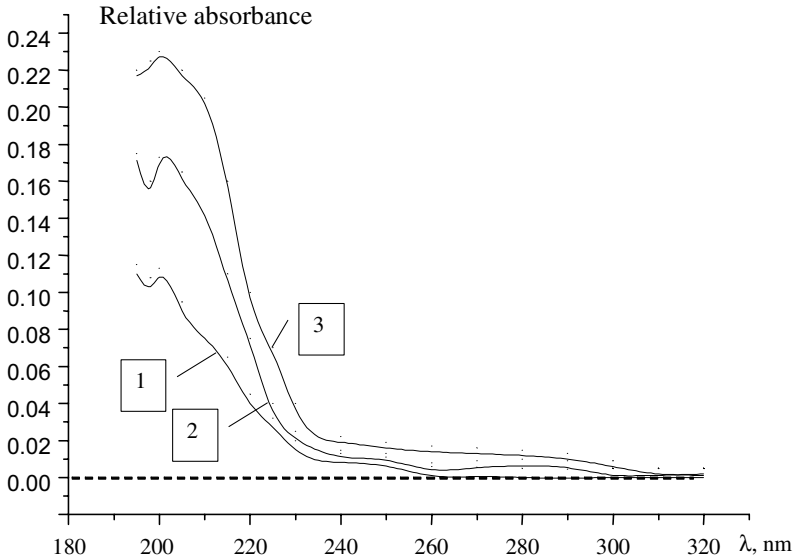


Figure 1.6. Changes in the optical density of distilled water irradiated by a continuous low-intensity SHF emission with frequencies: $\omega = 40.00$ GHz (1), $\omega = 45.55$ GHz (2), and $\omega = 53.55$ GHz (3).

process of activation is accumulative and depends not only on the excitation intensity, but also on the excitation duration.

It is of interest to note that though the total energy of the pulse SHF field, which passes through a cuvette, corresponds to 1 kJ and is two orders greater than that of the continuous irradiation, the resulting change in the optical density of activated water is much greater in the latter case. This result emphasizes the strong dependence of the effect of activation on the frequency of the action.

One more peculiarity of the results of these measurements consists in that the change in the optical density non-monotonously depends on the irradiation frequency: while the frequency grows from 40.00 GHz to 53.55 GHz, the optical density firstly decreases, and then increases to the maximum.

Gapochka's work in 1994 presents the study of the influence of intense SHF irradiation of water on the parameters of its NMR spectrum. The shift of the center of a NMR line was studied on a spectrograph "Tesla-BS-497" in 24 h after the completion of the activation of water. It was found that, for all three used methods of activation (continuous emission with frequency

$\omega = 2.45$ GHz, power of 450 W, and energy of 2.25 kJ; pulse emission with frequency $\omega = 2.71$ GHz, power of 800 kW, and energy of 0.92 kJ; pulse emission with frequency $\omega = 0.9$ GHz, power of 1000 kW and energy of 16 kJ), the center of a NMR line was shifted, respectively, by 32 ± 2 , 38 ± 2 , and 34 ± 2 Hz relative to the position of the control line for nonactivated distilled water. This displacement is related to an increase in the electron density in the region of a proton in a H_2O molecule.

We recall the optical density D connected with the coefficient of absorption $k''(\omega)$, the thickness of the medium L , and its dielectric permittivity $\varepsilon(\omega)$ by the relations

$$D = 2k''(\omega)L, \quad \text{and} \\ k''(\omega) = \frac{\omega}{c} \text{Im} \sqrt{\varepsilon'(\omega) + i\varepsilon''(\omega)} \approx \frac{\omega\varepsilon''(\omega)}{2c\sqrt{\varepsilon'(\omega)}}. \quad (1.9)$$

It is obvious that the increase in the optical density of water in the same cuvette of constant thickness L upon irradiation of the SHF field is related to both the increase in the imaginary part and the decrease in the real part of the dielectric permittivity of water $\varepsilon(\omega)$ in the UV region of the spectrum.

It is difficult to substantiate the presented results, if we do not account for the above-considered clathrate model of the mechanism of activation of water. The matter is that the change in the optical density of water in the UV range can be related only to stable changes in the electron configuration of water molecules. The experiments show that such changes preserve for at least 24 h.

It is known that any stable structural changes of the configuration of hydrogen bonds can only lead to a change of the specific features of the microwave spectrum and do not influence the spectrum of transitions in the UV range. At the same time, these effects can be rather easily substantiated, if we assume that the redistribution of the populations of isolated water molecules in the volume of clathrate microcavities occurs in the process of activation. If we take into account that the spectrum of the UV absorption of these quasifree molecules significantly differs from the spectrum of the UV absorption of bound molecules, then the change in the populations leads to a change of the absorption. In addition, it is possible that the above-considered anomalies in the absorption of activated water in the UV range are related to molecules of hydrogen peroxide which can be localized in microcavities of the clathrate frame.

1.3. Program, Equipment, and Research Techniques for the Investigation of Activated Water

The performed brief analysis of the existent models of water structure clearly demonstrates that water is an object which is much more complicated than a crystal or a gas. The above-considered results of numerous experiments testify that activated water has a number of specific physical properties. Many other experiments indicate that water activated in some way has distinctive memory and can render a strong influence on biological objects in a great time interval after the completion of the activation.

All these undoubtedly interesting results are uncoordinated, refer to completely different methods and modes of activation, and do not form a single logically connected system.

A significant drawback consists also in that the available studies have a highly specialized character. If, for example, the physical properties of activated water were studied, then the specific features of its action on biological objects were not considered. In particular, it is not known how the specific anomalous physical properties act on plants, microorganisms, animals, and men. On the contrary, if the specificity of action of activated water on a specific biological object was analyzed, its physical properties were not investigated.

Moreover, the registration of a definite character of the action of such water on biological objects of some type (for example, on a specific plant) does not allow one to forecast the result of the action on animals or plants of the other types.

Is the factor of the influence of activated water on living objects single and universal? Are there different mechanisms which adapt only to specific objects? How does the duration of activation of water affect the specificity of its action on different biological objects? To what degree do the anomalies of physical properties of activated water and the specific features of its action on a biological object correlate with one another? How do the duration and the mode of the storage of activated water affect the specificity of its action on biological objects?

We can pose infinite number of such questions but note that there are no answers to them in the literature. If the answers to similar questions are absent and the basic principles and the mechanism of action of activated water are not clear, the consequences of the use of activated water cannot be reliably forecasted.

As the above-considered general problems of activation of water, specific mechanisms and models of the long-term memory of water, and the analysis of specific features of the action of activated water on biological objects are very important and actual, we made the decision, jointly with our colleagues, to carry out a successive cycle of physical and biological studies of water activated in a single manner. We believed that this would allow us to perform not only the qualitative, but quantitative analysis of both the properties of activated water and the specific features of its influence on different biological objects and on different stress-involved situations (including, in particular, the presence of oncologic diseases).

Especially critical was the problem of the choice of a method of activation of water and the choice and the use of a specific device which would realize such an activation for the whole cycle of studies. First of all, we abandoned those methods of activation which can be conditionally named “force”.

Regarding “force” methods, we refer to those methods of activation which are related to the high-energy action on water (for example, the action of high-power emission or the action by ionizing fields). It is clear that, on such “force” action, there appear many side factors (for example, secondary radicals) not related to the very process of activation of water which is understood as the distinctive recording of the information in the bulk water without change of its charge or chemical state.

We also discarded the application of such methods of activation, with which it is difficult to get the reproducible characteristics of activated water. We considered that, in order to carry on the complex studies, it is worth using the standard seriously-produced device, whose characteristics are invariable and whose effect on water is the same for any number of acts of activation of various samples of identical water.

Based on such considerations, we performed a cycle of complex studies, by using the activator of water which was earlier studied by us and which allowed us to obtain a number of interesting, reliably reproducible and sufficiently convincing results in the whole spectrum of physical and biological applications.

Activation of water was realized with the help of a device whose principle of action is based on the so-called Molecular Resonance Effect Technology (MRET). It is described in a patent (Smirnov, 2000), and its author is one of the authors of this book. The preliminary information about this device is given in the book by Vysotskii, Smirnov and Kornilova (2005). This activator is the source of a low-intensity low-frequency complex field which

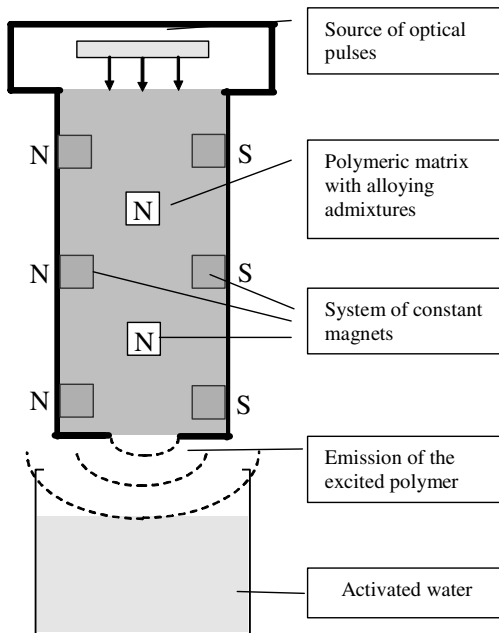


Figure 1.7. Scheme of a device for the activation of water due to the irradiation by a weak variable electromagnetic field.

has both electric and magnetic components and is registered only in the near zone of the working unit of the activator. We note that nobody carried out systematic successive physicochemical studies of water activated with this device.

The scheme of the device used for the activation of water is presented in Fig. 1.7. The structure of the device allows one to obtain a great amount of activated water with the identical characteristics.

The device includes the working body consisting of a polymeric matrix formed by oriented threads of a linear polymer (like the epoxy polymer) with the alloying admixtures of various chemical elements and compounds (including those in the form of an admixture of magnetic materials). The polymer itself, according to the patent, has both ferroelectric and piezoelectric properties. This polymer is surrounded by the system of mutually perpendicular pairs of oriented constant magnets, the field intensity of each magnet being 4000 Gs.

Above the upper part of the polymer, there is a matrix of light-emitting diodes, to which a pulse voltage with a repetition frequency of about 8 Hz

(in the range 7.2–8.2 Hz) is applied. These light-emitting diodes emit a sequence of optical pulses in the range of wavelengths of about $0.6 \mu\text{m}$. Optical pulses acting on the oriented polymeric system alloyed by admixtures create a redistribution of electric charges and a small deformation which leads to a periodic displacement of the electric charges and the alloying magnetic admixtures. The motion of the electric charges and the magnetic moments of atoms in the strong circular field of the constant magnets generates a variable low-intense electromagnetic field with complicated spatial structure. This field oscillates with the frequency of the repetition of optical exciting pulses and includes both the electric and magnetic components. The detailed description of MRET activator is presented in Chap. 2 and a detailed illustration is given in Fig. 2.7.

The generated electromagnetic field acts on water positioned near the open end of the polymeric activator and changes its structure, which is reflected in the long-term change of the properties of water. It is that the screening of the field by nonmagnetic materials (for example, with the help of a piece of thin glass, plastic, or even several layers of paper) significantly weakens the intensity of the action on water. Since the magnetic field is not practically changed at such a screening, it is obvious that the electric component of the variable electromagnetic field with a complicated configuration plays the significant role in the activation of water (for example, by means of the influence on the dipole moments of molecules and clusters in the bulk and on the surface of water). The influence of the magnetic component of the field and the general analysis of the action of a specific activator on the structure and properties of water will be given later.

The general view of two used activators with the identical polymer matrix is presented in Fig. 1.8.

The program of the study of the properties of activated water includes the execution of systematic complex studies in several fields of physics and biology:

- study of the physicomolecular characteristics of activated water (dielectric permittivity, conductance, refractive index, viscosity, efficiency of the Raman scattering, parameters of molecular motion, a value of the hydrogen index pH, etc.);
- study of the influence of activated water on “pure” microbiological cultures;
- study of the influence of activated water on the associations (cenoses and supercenoses) of microbiological cultures;



Figure 1.8. The general view of two used activators.

- study of the influence of activated water on higher plants;
- study of the influence of activated water on nonspecialized rapidly growing cell systems (like a callus tissue in botany or psoriasis in medicine);
- study of the influence of various fractions of activated water on the prophylaxis and the treatment of oncologic diseases, including the studies *in vivo* (mice) and *in vitro* (cells of various oncologic cultures); and
- study of the influence of various fractions of activated water on staphylococcal infection *in vivo* in animal model and *in vitro* on *Staphylococcus* culture.

The program foresaw the study of the properties of activated water at different durations of activation, different temperatures of the storage of water, and different durations of its storage after the activation.

We studied the influence of activated water on growth of microbiological cultures, on the efficiency of action of various antibiotics on these cultures, on basic biochemical reactions, on the formation of colonies, on the sterilization of various media from pathogenic cultures, etc. These studies were carried out under both aerobic and anaerobic conditions.

Since water of any type, being in the region where cells are dividing, renders direct influence on the character and direction of this process, one

of our principal aims was to investigate the influence of activated water on the processes of growth and division of anomalous cells (in the first instance, of oncologic tumoral cells). In addition, taking into account that activated water introduced into any real biological system will be inevitably mixed with ordinary nonactivated water already present in the system, we also planned to execute a number of experiments aimed at the study of the influence of such natural dilution on the efficiency of the action of activated water.

All these studies were realized fully, and their results are presented. In the course of the studies, we employed modern laboratory measuring facilities and up-to-date methods used in comprehensive systematic studies in various fields of physics, chemistry, microbiology, botany, biochemistry, and genetics.

The studies were carried out from 2004 to 2008 with the attraction of highly skilled experts from Kiev and Moscow. The list of the institutions which took part in our experiments is given in the Preface.