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HYDROPHOBIC INTERACTIONS IN AQUEOUS SOLUTIONS: THEIR OPERATION IN LIVING SYSTEMS

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Evidence is provided for the enormous role of hydrophobic interactions in aqueous solutions. It is concluded that complementary functions of hydrophilic and of hydrophobic species are in continuous operation and that these are a *conditio sine qua non* for the *existence* of the liquid. With regard to the supermolecular aggregations, hydrophobic interactions are operative on the highest hierarchic levels of the system organization, i.e. at the interface and at the holes around dissolved hydrophobic species. It is further emphasized that water is essential both for the unity and for the differentiation of each living organism. With regard to its role for the differentiation of the body, the hydrophobic interactions are of paramount importance, notably those provided by amphipathic solutes. The cell membrane is considered to be the result of interactions between the highest hierarchic levels of intracellular and extracellular water. The hydrophobic double layer provides the barriers for the separation of intracellular and extracellular water and at the same time the connections for recognition and for exchange of information between them. The DNA structures obtain conservative boundary conditions for their surrounding water systems which do not freeze at −60 °C. These water systems are dynamically superior to all other parts of the water system of the organism. It is suggested that more knowledge about the abilities of liquid water can be obtained by giving appropriate attention to its properties within the living body. © 1997 by John Wiley & Sons, Ltd.

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INTRODUCTION

Water molecules are unique in exciting both strong donors *and* strong acceptor functions of about equal strengths.[1] By their mutual interactions, a three-dimensional hydrogen-bonded structural network is established, which is highly adaptable to changes in conditions.[2] Quantitative data refer to the ‘diffusionally averaged structure’[3] with relaxation times of 10^{-11} s.[4]

Modern computational calculation methods have been applied to systems containing a number of molecules comparable to that in bulk systems.[5–7] However, it has not been possible to determine precisely the optimal configuration for the idealized unit of trimeric water,[8] such as has been obtained for the dimeric unit.[9] The present situation has been characterized as follows:[10] ‘No theory on water structure has been proposed that is predictive, theoretically sound and suitable to account for the quality of the liquid.’

Because liquid water is actually a solution from which the last traces of both hydrophilic and hydrophobic solutes cannot be removed,[2, 11–13] we suggested extending the molecular concept and treating the liquid under consideration as a highly differentiated, well organized, flexible macromolecule.[11–13] In order to gain an understanding of the qualities, we started from the wealth of observations under complex conditions and took into consideration the unavoidable presence of both hydrophilic and hydrophobic solutes.[11–13]

HYDROPHILIC SOLUTES IN WATER

The presence of hydrogen ions and hydroxide ions is a consequence of the self-ionization equilibrium.[13] These strongly hydrated ions are considered as ‘hydrophilic solutes’. Their hydration spheres have no borderlines as the hydration effects extend in principle over the whole liquid and finally reach the interface. IR and NMR spectra of solutions of hydrophilic solutes reveal spectral changes which simulate the effects of a decrease in temperature of the spectrum of highly purified water.[14] The increase in local densities within the hydration spheres is associated with increased local denisities at the interface areas,[13] as reflected in the well known effects of the decrease in vapour pressure and of the increase in surface tension.[2]

The bond length variation rules[1] expresses the fact that each molecular interaction is bound to lead to appropriate changes in the terminal regions of the system under consideration. A striking example of this effect is provided

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by the actions of haemoglobin within the human body.[15, 16] When oxygen molecules are coordinated at the iron sites of this molecule, the O=bonds and the Fe—N bonds are lengthened. These changes are associated with enormous conformational changes of the polypeptide chains, which led Perutz[16] to compare the oxygen molecules with ‘fleas, that make an elephant jump’. Structural investigations show that the coordinated oxygen molecules are rotating within the pockets of the haemoglobin molecules and these rotations are in accord with the movements of the polypeptide chains forming the pockets.[17] The transformation from haemoglobin to oxyhaemoglobin is accompanied by an intramolecular transformation from the paramagnetic high-spin into the diamagnetic low-spin state. During the course of this spin transformation, the molecule has optimum flexibility and adaptability towards its environment.[18] Within the erythrocyte, the haemoglobin molecule is surrounded by the cytoplasm of the cell. As soon as oxygen molecules are coordinated at the iron sites, two protons are released into the cytoplasm from the ends of the protein chains separated by 146 amino acid residues from the iron atoms of the haem groups. In this way, carbon dioxide available in the cell plasm as hydrocarbonate ions is set free in the lungs. When oxygen is released in the tissues, two protons are attracted from the cell plasm by the terminal boundaries of the haemoglobin molecule, so that the conversion of carbon dioxide into hydrogencarbonate ions is facilitated in the cell plasm.

The interdependences and specific interactions between haemoglobin and oxygen on the one hand and between haemoglobin and the cell plasm on the other suggest an ‘intelligent behaviour’ at the molecular level.[19] Eigen and Winkler[20] referred to molecules which respond in highly specific ways to changes in environment as ‘intelligent molecules’.

HYDROPHOBIC SOLUTES IN WATER

Less attention has been paid to the presence of small amounts of dissolved gas molecules in water. They appear to ‘refuse’ directed covalent bonding to water molecules and are called hydrophobic solutes. Examples are oxygen, nitrogen, hydrocarbons, ethers and carbon tetrachloride. The solubility of hydrophobic substances in water is usually at least one order of magnitude smaller than the solubility of water in the hydrophobic liquid under consideration (Table 1).

Gas molecules contained in clathrates in liquid water are known to be entrapped in cavities,[21–23] which are larger than required for their inclusion in the holes. Some of the cavities remain unoccupied and yet they are stable. Their stabilities in liquids have been demonstrated on theoretical grounds.[24] Their existence implies inner surface areas with tightly bound water molecules and non-covalent interactions with the hydrophobic solute molecules. The O· · ·O distances enclosing a cavity are shorter for unoccupied than for occupied cavities,[25] as expected on the basis of the bond length variation rules.[1, 26, 27] The structural features around a hole of the dimensions found in the clathrate structures are illustrated in Figure 1 by applying the bond length variation rules.[1, 2, 13]

According to the non-covalent interactions between water and the entrapped gas molecules, the latter librate or rotate within the limitations provided by the flexible boundary conditions of the inner surface areas of the holes.[28, 29] These motions are reflected in high values for the heat capacities of the dissolved gas molecules, which have been estimated to be nearly as high as in the gas phase.[30] The investigation of the vibrational spectrum of the solution indicates changes similar to those arising from an increase in temperature for ‘pure’ water, i.e. the liquid structure is ‘loosened’, becoming more ‘water-like’.[14] The results of ^{13}C NMR and spin–lattice relaxation time measurements suggest that water restricts the motions of the hydrophobic solute moieties in conjunction with a concomitant influence on the motions of the neighbouring water molecules,[31–33] but the hydrogen-bond network remains essentially unaltered.[34]

This shows that the inner surfaces of the cavities provide a kind of conservative boundary conditions for the librations of the gas molecules (see later), which are influenced by the

Table 1. Solubilities of hydrophobic substances in water and of water in hydrophobic liquids at 25 °C

Hydrophobic substance	Mole fraction of hydrophobic substance in water	Mole fraction of water in hydrophobic liquid
Pentane	$9{\cdot}5\times 10^{-6}$	$4{\cdot}8\times 10^{-4}$
Hexane	$2{\cdot}0\times 10^{-6}$	$3{\cdot}5\times 10^{-4}$
Benzene	$4{\cdot}1\times 10^{-4}$	$2{\cdot}7\times 10^{-3}$
Toluene	$1{\cdot}0\times 10^{-4}$	$1{\cdot}7\times 10^{-3}$
1,2-Dichloroethane	9.2×10^{-4}	1.1×10^{-3}
Chloroform	$1{\cdot}2\times 10^{-3}$	$4{\cdot}8\times 10^{-2}$
Carbon tetrachloride	9.0×10^{-5}	$5{\cdot}4\times 10^{-4}$
Methane	$2{\cdot}5\times 10^{-5}$	–
Oxygen	$2{\cdot}3\times 10^{-5}$	–
Nitrogen	$1{\cdot}\dagger 2\times 10^{-5}$	–

structure of the liquid as modified by the hydrophilic solutes. The stability of the whole solution requires that a certain synchronization between the oscillations of liquid structure and the gas molecules must be in operation.[2] This means that the dissolved gas molecules seem to have the remarkable ability to take over structural information from the solution structure as inscribed by the hydrophilic solutes and to preserve this structural information dynamically within their oscillations in harmony with those of the solution. Such adaptation between the oscillations of the solution pattern and of the gas molecules implies continuous exchange of information between them, which presupposes a relationship between sender and receiver, a kind of common language understood by both of them (see later).

Because it is impossible to remove the last traces of gas molecules from the liquid phase, the non-covalent interactions between water and the gas molecules must be well integrated into the hydrogen-bond network so as to provide for the dynamic properties of the liquid. As the temperature is lowered, the increasing rigidity of the network is compensated by the increasing gas concentration, which is dramatically increased as supercooled water is produced. It is also increased when the differentiation of the solution is decreased by purification of the solvent. Evidence for comparatively strong hydrophobic interactions has been found for the non-polar nucleotide rings in DNA.[35,36] It has been suggested ‘to consider the hydrogen bonds as providing the structural specificity of the DNA double helix rather than the major driving force for the association.’[37]

In agreement with the complementary functions of hydrophobic and hydrophilic solutes, addition of hydrophobic solutes to water leads to changes in solution properties which are opposite to those caused by the addition of hydrophilic solutes. Surface tension and density

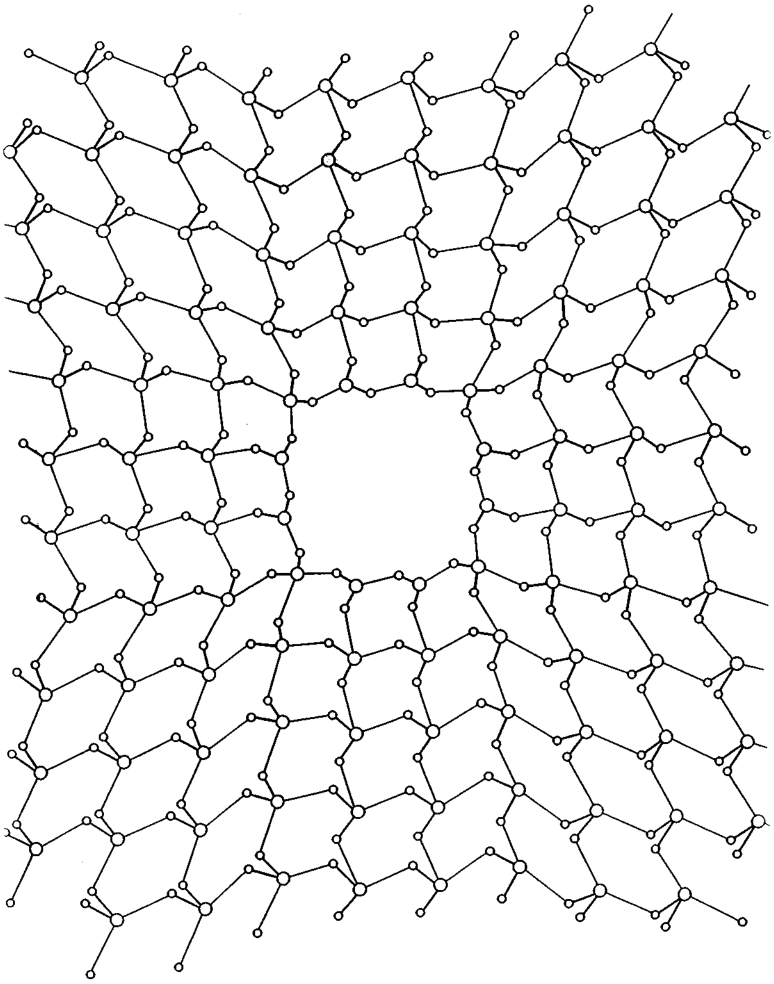

Figure 1. Idealized two-dimensional illustration of the water structure around a hole

Table 2. Changes in solution properties by addition of hydrophobic and hydrophilic solutes to water

Property	Hydrophobic solutes	Hydrophilic solutes
Surface tension	Decreased	Increased
Vapour pressure	Increased	Decreased
Density	Decreased	Increased
Specific heat	Increased	Decreased
Water structure	Less dense	More dense
Particle movement	Rotation	One-dimensional
Vibrational spectra correspond to those of pure water at	Higher temperature	Lower temperature
Static aspects of 'water structure'	Decreased	Increased
Dynamic aspects of 'water structure'	Increased	Decreased

are decreased by hydrophobic but increased by hydrophilic solutes, whereas specific heat and vapour pressure are increased by dissolved gas molecules and decreased by hydrophilic solutes (Table 2).[2] This shows that hydrophilic and hydrophobic solutes have complementary functions within the liquid.

HYDROPHOBIC INTERACTIONS AT THE PHASE BOUNDARY

The phase boundary does not provide a simple or sharp termination of the liquid phase because it undergoes continuous interactions with the adjacent phase. The existence of both phases requires both strong hydrogen bonding between the water molecules at the interface in order to preserve the existence of the liquid and hydrophobic interactions between the liquid and the adjacent phase[34] in order to maintain a certain distance between them and to provide a certain protection from complete mutual penetration, which would result in the disappearance of the phase boundary with the formation of the new one-phase liquid system.[2]

For example, the miscibility of water and sulphuric acid is due to the dominance of hydrophilic interactions between their molecules. The same is true for the high solubility of sodium chloride in water. Water and alcohol are completely miscible because the hydrophobic interactions of the ethyl groups are well integrated into the liquid mixture. On the other hand, a phase boundary is readily established between diethyl ether and water, because of a lack of hydrophilic interactions. Likewise, the phase boundary between water and air is due to the hydrophobic properties of most of the molecules contained in air.

The decisive contributions of hydrophobic interactions at the interface appear to manifest themselves in the changes in macroscopic properties as the interface area is increased by a decrease in thickness of the water film. The temperature range for the existence of supercooled water is extended and the freezing point is lowered as the drop size is decreased or as the surface of the glass tube of a given diameter is coated by a hydrophobic layer.[38–48] The lowest freezing point of −44 °C is obtained for droplet diameters below 1 μm in the hydrophobic environment provided in the cloud chamber. Another major reason for the existence of supercooled water involves the increase in gas concentration with decrease in temperature because of the negative temperature coefficients of gas solubilities.[41, 42] Water in extremely thin layers exhibits very low phase transition temperatures: a bilayer of water molecules remains liquid down to −38 °C,[43], i.e. its liquid structure is considerably more loosened than in the bulk phase.[44]

The improvement of the dynamic properties by an increase in the interfacial area is reflected in the heat capacities: these are 10% higher for water in 24 nm diameter silica pores than for bulk water,[45] with a minimum heat capacity at 24 °C. A decrease in density has been found for water contained in 14 nm diameter silica pores[46] and for water adsorbed on sodium bentonite over a distance of 6 nm from the clay surface.[47] Similar volume changes have been found by means of high-precision density measurements on suspensions of solid particles.[48]

Another observation which indicates the role of hydrophobic contributions at the interface is the tendency of water to exclude electrolytes near the interface, thereby increasing the concentration of the electrolyte at some greater distance from the interface.[49] It is further known that the properties of clay minerals used in ceramics in the brick and cement industry are essentially dependent on the hydrophobic contributions to the clay–water interactions for the achievement of optimum plasticity and coherence. This knowledge has been empirically acquired and leaves plenty of room for fundamental research.

Owing to the specific mutual interactions between the phases, all quantities measurable at the interface are more or less influenced by changes in environment. This is the reason why poor reproducibilities of values of surface tension[50] and heat capacities in thin layers[45] have been reported.

AMPHIPATHIC SOLUTES IN WATER

Amphipathic solutes are characterized by molecules with hydrophilic properties at one end and by hydrophobic properties at the other end. The former are also called (hydrophilic) head groups and the latter (hydrophobic) tails. By means of their hydrophilic head groups the molecules remain well integrated within the aqueous phase and by means of their hydrophobic tails they repel water.

The hydrophobic tails tend to escape the aqueous phase, whereas the hydrophilic head groups remained well ‘anchored’ in the aqueous phase. Thus, the hydrophobic tails project out of the water with formation of a hydrophobic layer at the interface.

A different arrangement results from tail-to-tail interactions of the hydrophobic chains between two different layers, so that within the liquid phase water-insoluble films are produced in form of bilayers.[2] These bilayers are formed within the liquid structures and they remain part of the highly differentiated liquid. They separate different aqueous regions from each other and connect them at the same time without completely losing their liquid properties (cell membranes, see later).

Instead of forming bilayers, association of the hydrophobic tails may lead to the formation of sphere-like aggregates, the micelles. In these the hydrophilic head groups are directed towards water in such ways that the hydrophobic tails are largely shielded from the aqueous phase[51] with the formation of a hydrophobic interior. Because the sizes of the micelles range from 5 to 20 nm, they give rise to the colloidal character of the solutions.[52,53]

SYSTEM ORGANIZATION OF LIQUID WATER

It has been pointed out that the differentiation of a material system is a condition for its capacity to act as a unity in its meaningful response to stimuli from outside whereby its main characteristics and functionalities are not lost.[3,44,54,55] In order to meet these demands, a material system cannot be a haphazard compilation of items or a complex of rigidly linked pieces, but rather a highly differentiated and hierarchically organised unity: a system organisation is a requirement for each real thing.[2,44,54,55]

This necessity has been discussed by Weiss[56] for living systems and aspects of organization have been described as follows: ‘As a unit is composed of subunits, the problem of the unity of a unit resolves itself into the question of what makes the component subunits cooperate in such coordinated manner as to establish and preserve the rather definite pattern of the compound unit. It may be a standard pattern of behaviour of the components that yields recurrently the same unitary result even though there is no geometric similitude among the constellations of the components from movement to movement. Such units are properly called systems … The state of the whole must be known in order to understand the co-ordination of the collective behaviour of the parts. … A system could, therefore, be defined as a complex unit in space and time so constituted that its component subunits, by systematic cooperation, preserve the integral configuration of structure and behaviour and tend to restore it after non-destructive disturbances.’

He further pointed out[57] that ‘the patterned structure of the dynamics of the system as a whole coordinates the activities of the constituents. In atomistic microdeterministic terms, this coordination would have to be expressed as follows: since any movement or other change of any part of the system deforms the structure of the whole complex, the fact that the system as a whole tends to retain its integral configuration implies that every change of any part affects the interactions among the rest of the population in such a way as to yield a net countervailing resultant; and this for every single part. Couched in anthropomorphic language, this would signify that at all times every part “knows” the stations and activities of every other part and “responds” to any excursions and disturbances of the collective equilibrium as if it also “knew” just precisely how best to maintain the integrity of the whole system in concert with the other constituents.’

This mould-breaking view has, however, remained without consequences for the development of biology, possibly because Weiss himself was not aware of the role of water in living bodies and its system organization. The supermolecular system organization of liquid water and its solutions has been presented in some detail[2,12,13,44] and illustrated by means of a truncated pyramid shown in Figure 2.

The molecules at and near the interface serve the highest hierarchical level that is accessible. The highly developed dynamic actions of these molecules exert a dominating influence over all the other parts. Immediately subordinated are the hydrophobic solute molecules and the water molecules surrounding them. Subordinated to this level are the hydrophilic solutes and their hydration spheres exerting a structurizing influence on the solution. The vast number of all other water molecules serves on the lowest hierarchical level, relevant for the structural and thermodynamic properties of the solution.

All of the hierarchical levels are necessary for the functions of the system under consideration as each of them serves certain irreplaceable objectives and goals for the whole liquid. As the external conditions are changed, the highest level determines in which way all is to be reorganized in order to maintain the chief characteristics of the system.[2,44,55] The well pronounced dynamic activities in the higher levels would be impossible without the non-covalent (hydrophobic) interactions.[2] On the other hand, covalent (hydrophilic) interactions are required in order to maintain the static and structural aspects of the lower levels, which appear to provide more conservative boundary conditions for the more dissipative actions in the higher levels.[2,55]

CONSERVATIVE AND DISSIPATIVE STRUCTURES

At this point it is important to note that a clear distinction between conservative and dissipative structures is not possible. Conservative structures are considered to be formed and maintained through ‘reversible’ transformations, implying no appreciable deviation from equilibrium. Dissipative structures are formed and maintained through exchange of energy and matter under non-equilibrium

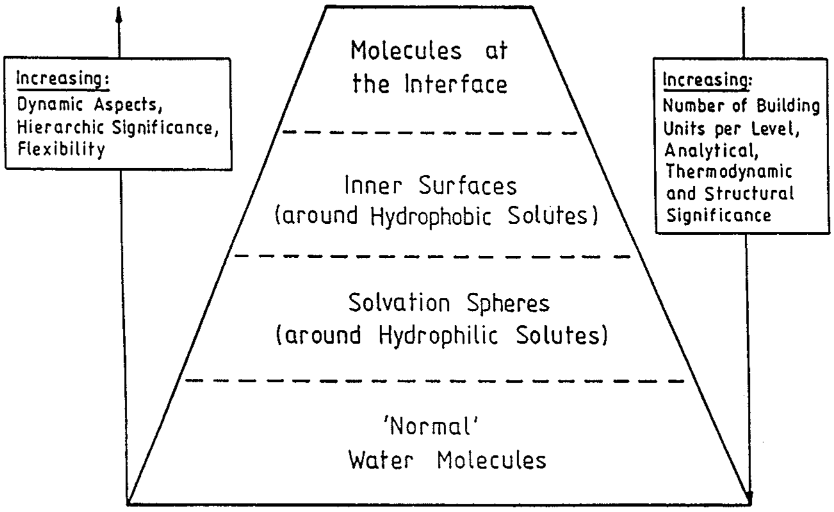

Figure 2. Illustration of the system organization of liquid water by means of a truncated pyramid

conditions and they may be considered as ‘giant fluctuations’ staiblized by the flow of energy and matter prescribed by the conservative boundary conditions.[58] In the absence of dissipative actions, a conservative structure could not respond to any change in environment, such as in temperature. On the other hand, a dissipative structure could not develop on its own as it is bound to follow certain conservative boundary conditions, which at the same time are modified by the former. Their mutual interdependences and complementary functions are required for existence and observation of things.[2]

These facts have been illustrated by considering a river.[2,55] The conservative boundary conditions are provided by embankment, river bed and gravitational forces. The river bed and embankment are slightly, but continuously altered, even if the speed and the quantity of water remain nearly constant. The conservative boundary conditions are altered increasingly, the greater are the changes in the rate of flow. With a reduction in the quantity of flowing water, the river bed will become silted up, whereas an increase will cause the river to overflow, the bed to deepen and the banks to change their shape. In other words, any change in dissipative features (rate of flow) causes changes in conservative features (river bed), and these in turn have an influence on the dissipative aspects. Thus the latter follow the former, and these provide boundary conditions for the dissipative aspects.

As long as only the structural features and their quantitative characteristics are taken into account, the consideration of covalent bonding is sufficient, which describes the static and quantitative aspects. However, in order to provide an understanding of the dissipative features and of the qualities, attention must be paid to non-covalent bonding. This involves the ‘freedom’ that is required for an understanding of quality, i.e. ‘form in motion.’ Since both quality and quantity are found on each object and since they can be distinguished, but not separated from each other,[2] it is important to study both the conservative and the dissipative aspects and in particular those which appear less pronounced: for a knowledge of conservative structures, their dissipative aspects should be studied in more detail, and for an understanding of dissipative structures, the conservative structural aspects should be given appropriate attention. The material aspects of a concrete system appear to be realised within the ‘field of tension’ between conservative and dissipative forces. A predominantly dissipative pattern is more open, more adaptable, but also vulnerable, whereas a predominantly conservative structure is more rigid and resistant to structural changes.[2]

The dissipative aspects are highly developed in the gaseous state, their molecules are highly differentiated and the actual volume depends on the external boundary conditions, whereas the conservative aspects are highly developed in the crystalline state. The liquid state of aggregation is found somewhere between the solid and gaseous states. Its dissipative aspects are much better developed than in a crystal and less pronounced than in a gas and the conservative aspects are less pronounced than in the crystal and better developed than in a gas. A liquid may therefore be considerd as a system in which the static and the dynamic aspects are more ‘balanced’ than in either a crystal or in a gas.[2]

WATER AND THE DIFFERENTIATION OF THE HUMAN BODY

As a result of its inner organization, water must possess many more characteristics that are not accessible in the course of physico-chemical experiments, but can be inferred only from its contributions to living systems, as exhibited by their specific life functions.[2] Water provides the material basis both for the unity and for the enormous differentiation of the organism. Accordingly, every type of living phenomenon owes its existence to a certain capacity of water to ‘handle’ information by means of specifically differentiated structures and this may be illustrated by considering the cell membranes.

The human body contains hundreds of trillions of individual cells, all of them in continuous cooperative interactions. The highly differentiated cell membrane separates and connects intracellular and extracellular water. The intracellular region retains the individuality of the cell and it acts ‘structurizing’ for the differentiation of the organism. It contains boundaries for subunits, the mitochondria, the microtubules and the microfilaments, all of them cooperating in maintaining the individuality of the cell. The extracellular regions are structurally less differentiated and they give unity to the organism, whereby each cell serves an individual purpose within the whole in cooperation with all other cells. This requires that (1) certain characteristic features are maintained (conservative structures) and (2) certain changes and alterations are taking place with the development of new structural features and these are manifestations of dissipative structures.

The fluid cell membranes consist mainly of bilayers of phospholipids, of proteins and of water. The bilayer is made up of an internal and an external monolayer of amphipathic lipid molecules. By means of the hydrophilic head groups of the amphipathic lipid molecules the former is anchored in intracellular water and the latter in extracellular water. The monolayers are held together by the interactions between the hydrophobic tails of the lipid molecules. At the same time, the hydrophobic double layer provides the actual barrier between the two liquid phases and this is reflected in the high electrical resistance of the membrane. In this way the hydrophobic barriers help to maintain a certain distance between the aqueous phases and to direct their respective abilities ‘inwards’ so as to maintain their main characteristics.[2]

The hydrophobic interactions provide for a certain ‘fluidity’ as well as for the enormous strength of the membrane, which appears supported by the functions of the protein groups. It has been pointed out[2] that the internal monolayer is the phase boundary of intracellular water and the external monolayer the phase boundary of extracellular water. As their phase boundaries provide the highest hierarchic levels of the respective water systems, existential combat is continuously taking place between these aqueous phases.

This requires that information from both phases is available at the hydrophobic double layer. All changes near the hydrophilic head groups result in characteristic changes in the membrane properties. Accumulation of ions near the hydrophilic head groups leads to partial dehydration of the latter and to subsequent tightening of the hydrophobic tails, i.e. to narrowing of the channels between them. As ions near the head groups are removed from them, the hydrophilic channels will be widened. Such changes are influenced according to the exchange of information that is taking place between the hydrophobic tails of the interacting monolayers.

The cell membranes represent the highest hierarchical levels of the fluid aqueous systems, and hence they are highly organized so as to provide ideal conditions for appropriate communication and exchange of energy and matter according to the demands of the whole body.

WATER AND THE UNITY OF THE HUMAN BODY

On the material basis, the unity of the human body is provided by its aqueous system, which penetrates all of its areas and is a *conditio sine qua non* for all events in a living system.[2] This may be illustrated by reconsidering the genetic information which is believed to be provided by the DNA structure. However, the genetic information is lost by its complete dehydration with simultaneous breakdown of its structural framework and it is not regained by rehydration. The non-freezability of water immediately bound to DNA down to -60 °C,[59] the lowest temperature ever observed for liquid water under atmospheric pressure, leads to the suggestion that water in immediate contact with DNA molecules is even better organized than in the supercooled state.[2, 41] Such highly developed dynamic forces seem to be the reason why this sphere of water exercise the most decisive influence on all other water spheres within the body, as these do not possess such a high energetic level.

Thus, DNA molecules and water surrounding them act as a unity in maintaining the basic genetic information. The water layer is extremely thin and situated between the hydrophobic conditions of the cell nucleus and the backbone of the DNA structure, which provides the conservative boundary conditions for the genetic information without being the sole bearer of this information.

The formation of DNA molecules takes place within and under the influence of the aqueous system of the organism with the help of certain enzymes, also produced within the water system of the body. This presupposes that water must already possess in itself a certain capacity to ‘handle’ information under *in vivo* conditions by means of its specific and differentiated structures. It must be able to integrate other stimuli within its own oscillating network, i.e. to ‘translate’ information from other forms. Water seems to ‘understand’ the languages of other forms and to ‘translate’ incoming information into its own language, the ‘*water language*’ which is the universal language within the organism.[2] Unfortunately, there is no direct access for man to understand this language with the information content carried and transmitted in this way. However, this language seems to be understood by all subsystems interacting within the living organism. The question of where the information comes from is beyond the scope of scientific considerations since this is a question of realistic philosophy.

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