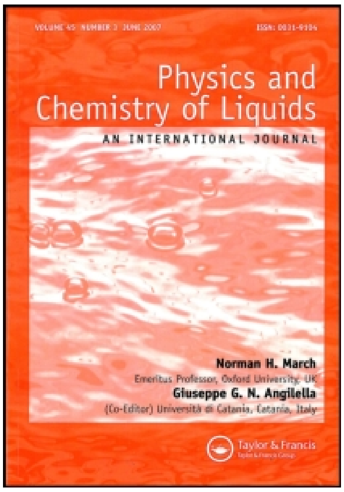

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Water Opening Address in the Presence of His Majesty the King of Belgium

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Water

Opening Address in the Presence of His Majesty the King of Belgium

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Solvay conferences aim to have two main characteristics. In planning them, our Scientific Council first chooses a unifying theme to link together diversified lines of scientific research, in which recent advances have been rapid. Leading scientists concerned with these advances are then invited from all over the world to Brussels, to present their successes—and their difficulties—to one another and to a small audience also specially invited. As is well known, spearhead advances in modern science must concentrate their attack on a fairly narrow front to make effective progress. But this very concentration often leads to a spread of advances in widely separated directions, like the fingers of a starfish. Those moving along one finger of the star can be wastefully ignorant about the other fingers. At Solvay conferences, by bringing experts in different lines together, our purpose is to encourage cross-communication of suggestive ideas and to promote mutual borrowing of scientific techniques. Measured by size, compared with very large scientific conferences now organized all over the world, Solvay conferences remain an "elitist" mode of scientific communication, in the sense that the number of invited experts is deliberately kept rather small, and that abundant time is provided for discussions. Discussion proceedings are fully recorded and their subsequent publication in book form is of course read by a much greater number of scientists afterwards.

At this fifteenth Solvay Conference on Chemistry, our unifying theme is "water." Adult people themselves consist of water up to about 70%, and it is perhaps not surprising that from prehistoric times water has been a theme for innumerable often poignant discussions by leaders of human beings of many

† Presented at XVth Solvay Conference on Chemistry, "Electrostatic Interactions and the Structure of Water," Brussels, 1972.

descriptions. Engineers and scientists, in particular, spent much of the nineteenth century discussing water as a liquid giving rise to steam, water as a solvent, and water as an electrolyte. Whilst these topics are still highly important, modern advances during the past 30 years have been particularly concerned with those properties of water that can be correlated and interpreted in terms of its atomic structure. Powerful new methods of studying this structure, such as nuclear magnetic resonance, have been combined with refinements of more classical methods, such as x-ray diffraction.

We will be discussing modern ideas about the structure of water with—at the centre of the star—the introductory conference paper by Professor Magat from the University of Paris. One can picture water as a three dimensional network liquid. Oxygen atoms of each H_2O molecule can act as knots. The links between the knots are called hydrogen bonds. Each knot can, at the very most, be linked to four neighbouring knots tetrahedrally, though in liquid water knotting is incomplete: only in ice does this three dimensional network have orderly lattice regularity. In liquid water, a kind of nightmare irregularity is found, and the enormous versatility of functions of water arises in part from the fact that an enormous variety of irregular knot patterns can readily be introduced locally, without high strain. In three dimensions, possible irregularities of knot patterns and of network structures of water are far greater than in two-dimensional imperfect networks such as worn old fishing nets, to quote a homely example.

All I have said refers to pure water in bulk. But furthermore, various kinds of physical perturbations can be imposed on pure water. In physical chemistry the principal perturbations can be classified; each type tends to impose its own distinctive type of knot pattern irregularity: this may be illustrated by reference to various invited contributions that will be discussed at this Solvay Conference.

We will start along one finger of the star with the classical case of aqueous ionic solutions. Professor Desnoyers from Canada will deal with the local rearrangements imposed by the intense electrostatic forces acting on H_2O molecules. These forces emanate from each individual charged ion in aqueous solution. Problems of ion hydration though classic are still far from being fully resolved. Modern techniques of study offer new prospects of advance, by permitting new kinds of measurements, as well as tests of refined physical theory.

Whilst ion hydration can be described as a point perturbation, our conference will also consider, along a second finger, perturbations of the water structure at interfaces which are extended. Professor Randles from Great Britain will present for discussion modern views about structures and related problems at water/gas interfaces. As a third finger, Professor de Bruyn from the Netherlands will deal with the extended interface between water and solids or liquids, when these are dispersed throughout its bulk, as colloid particles.

Special situations arise when an electric current flows through an aqueous electrolyte. At each electrode, ions take part in charge transfer processes gaining or losing electrons rather like customers in a Bank drawing out or paying in money. Unlike the banking analogy, jumps or tunnelling of electrostatic charges from individual ions in solution to the electrode are not fully understood. In some cases discharged ions form an electroplated deposit. All these problems are, of course, of enormous industrial as well as scientific importance. As the fourth finger, modern ideas about the distinctive processes at the hetero-interface between an aqueous ionic solution and an electrode will be discussed by Professor Reddy from India.

In all biological masses, including our own bodies, various roles of water raises scientific questions that are only just beginning to be formulated adequately in terms of modern ideas about the molecular network structures of water. As an important instance, the structure of water can be intimately modified by the neighbourhood of protein. Proteins themselves cannot in fact have a molecular structure attributed to them adequately without also specifying the role of the pervasive interpenetrating H_2O molecules. Much molecular biology is wrapped up with scientific advances in our knowledge about the structure of water at hetero-interfaces with the biomass. To complete our starfish we are fortunate in having a contribution from Professor Drost-Hansen of the U.S.A. to guide our conference discussions of these problems. Though possibly inexhaustible, their future development now seems promising, and is certainly intriguing.

In considerations about water structure, we are not just dealing with static patterns. The time-dependence of structural changes is also important. In one Solvay Conference it is not possible to do full justice to all kinetic aspects of structural change. However, in a kind of supplementary finger of our starfish, our discussions will include ion exchanges and time-dependent relaxations of water structure starting with a contribution from Professor Fripiat of Belgium.

Water, protean as ever, will undoubtedly spew forth new creatures to populate the world of science. It is our hope that some will begin to creep or even walk on solid earth, at our fifteenth Solvay Conference.