

to live together and to cooperate and to communicate. Scientists are themselves sometimes excellent ambassadors.

Eighty-two years ago when this Association met here in Montreal, young William Osler was professor of the Institutes of Medicine at McGill. He reported his early work on blood in three short papers. No one, in his generation, did more than he to draw three great nations together—Canada, United States, and Britain.

Like Osler, the physicist Ernest Rutherford moved through the Eng-

lish-speaking world. He received his early education in New Zealand; began his research on the atom at McGill University; and then sailed away to carry on his epoch-making investigations at Manchester and Cambridge Universities. His disciple, Peter Kapitza, today works in the Soviet Academy of Sciences. Kapitza is director of the Moscow Institute of Problems of Physics, Academy of Sciences, U.S.S.R. Lev Landau and others interested in the properties of substances at low temperature work under his direction.

You and I and all men of science, except the few involved in defense research, are communicating constantly with scientists in every land. The flow to mainland China is voluminous. They will soon be reciprocating. Pray God the peoples of this world will learn, before it is too late, to be friends and exchange information and thought on every level of society. Only thus will all men come to know and understand their counterparts, their opposite numbers, on every side of every barrier and boundary. When that day dawns, peace will be secure.

Reports of Symposiums

Hydrogen Bonding

Hydrogen bonds are as common in nature as ordinary chemical bonds, and it may be stated with but slight exaggeration that they are equally important. They hold together the molecules in ice and in liquid water. They often provide the greater part of the forces that act on molecules dissolved in a solvent. They are present in electrolytes and in many crystals and rocks. There are billions of them in every living organism including our own bodies, and they are most important for the basic mechanisms of life. Thousands of research papers have been devoted to hydrogen bonding.

A well-remembered symposium on problems related to hydrogen bonding took place in 1957 in Ljubljana, Yugoslavia. The aim of another one-day symposium, part of the annual congress of the American Association for the Advancement of Science (Montreal, 29 December 1964), was to point up new developments in the field since 1957.

A review concerning wave-mechanical treatments of hydrogen-bonded systems was presented by S. Bratoz (Centre de Mécanique Ondulatoire Appliquée, Paris). The most reliable detailed calculations made recently are related to the $(\text{FHF})^-$ system. The

hydrogen bond holding this ion together is the strongest known hydrogen bond; it is of fundamental importance because of the relative simplicity of the system. There are "only" 20 electrons in this ion and it is now possible to include all of them explicitly in the calculations. Such "exact" calculations were made (among others) by Clementi and MacLean and by Bessis and Bratoz. The former computed the total energy of the ion with good accuracy; the latter, its dissociation energy in fair agreement with experiment. They have shown also that only the ground state is stable; it is characterized by diminution of the electronic charge density around the proton as a consequence of the formation of the hydrogen bond and by a corresponding increase around the fluorine atoms. In the first excited state, the electronic charge would increase around the proton, a fact connected with the instability of this state. Bratoz pointed out that such exact calculations are now possible for somewhat more complex systems.

For rough purposes, fragmentation of the hydrogen-bond energy into electrostatic, delocalization, repulsive, and dispersion contributions seems still to be admissible, although, as Bratoz has shown, the importance of the electron migration which is consecutive to

the hydrogen-bond formation should be stressed much more. There is a similarity between hydrogen-bond forces and charge-transfer forces which offers a useful new way of looking at hydrogen-bonded systems.

Much of our knowledge of hydrogen bonding is based on spectroscopic and other measurements on solids or liquids in which we actually observe cooperative effects between many hydrogen bonds or one hydrogen bond perturbed by strong environmental effects. Therefore study of hydrogen bonding in the gas phase is of fundamental importance if we require knowledge of just one hydrogen bond; such work was reported by H. J. Bernstein (National Research Council, Canada).

Bernstein and his collaborators measured the infrared spectra of systems like methanol + triethylamine which, under adequate circumstances, remain hydrogen bonded in the gas phase. They used the results of their measurements at various temperatures and pressures for determining the energy (enthalpy) of the hydrogen bond ΔH . Using thermochemical cycles, Bernstein derived relations between ΔH and $\Delta \nu$, the difference of the X—H stretching frequency of the free and associated species. These relations involve the dissociation energy of the H—A radical (A being the proton acceptor) which can be computed from the data. An interesting result is that species like the neutral NH_4 radical are predicted to be stable.

Another remarkable result of Bernstein's gas phase studies is that although $\Delta \nu$ in the gas is essentially the same as in the condensed phases the bandwidth is much less.

There was animated discussion of possible explanations of the breadth

problem, that is, of the fact that the infrared X—H stretching frequency gives, in most cases, an extremely broad band. Much of this breadth is due to overtones and combination tones of lower-frequency vibrations of the molecules which are involved, their intensities being often enhanced by Fermi resonance with the X—H vibration. Another part of the breadth comes from combination tones between the X—H frequencies and low-frequency vibrations of the bridge itself which are coupled to the X—H vibration by a fair amount of anharmonicity. In condensed phases a part of the anharmonicity may come from coupling with intermolecular vibrations. It appears to be a most important quantity for understanding the phenomena related to hydrogen bonding. Double well-shaped potential surfaces are possible in certain cases; these may cause splitting of the bands but would not explain the broadening of them.

Recent progress has been great in x-ray and neutron-diffraction structure determinations on molecules containing hydrogen bonds. R. Pepinsky (Florida Atlantic University) rather impressively reviewed work done in his own and in other laboratories. X—A distances are known with great accuracy in many cases, but the position of the proton determined by x-ray techniques is still quite uncertain. The departure from linearity is accurately known for a number of bonds: for example, the XHA angle is 140 deg in nickel-dimethylglyoxim. No good relations exist between distances and hydrogen-bond energies. Among the interesting cases studied by Pepinsky were a number of hydrated and glycine or glycinium derivatives. In water, hydrogen bonds appear to be bent; in KD_2PO_4 , the bond is slightly longer than in KH_2PO_4 .

E. D. Becker (NIH) reviewed applications of high-resolution nuclear-magnetic resonance (NMR) spectroscopy to the study of hydrogen bonding. The NMR technique has certain unique advantages for studies of hydrogen bonding: the sensitivity of the chemical shift to hydrogen-bond formation; the dependence of spin-spin coupling upon hydrogen-bond formation; and the possibility of using various solvents, especially deuterated ones. At the same time certain shortcomings should be recognized: with NMR we measure only the *average* chemical shifts and coupling constants

due to rapid formation and breaking of hydrogen bonds; and there are the low sensitivity of the method and the sensitivity of the observed phenomena to small amounts of water. Much is to be gained by using NMR in conjunction with infrared and ultraviolet spectroscopy.

Spin-spin coupling constants increase on hydrogen bonding. Becker reported on his new results obtained with aniline- N^{15} : the N^{15} —H coupling constant increases by about 5 percent on hydrogen bonding; and the O—H . . . $N^{15} \rightleftharpoons O \dots H-N^{15}$ tautomerism also can be studied and information on the potential well can be obtained.

Becker's other experiments included investigation of the interaction of a highly hindered alcohol with dioxane, both in CCl_4 and in cyclohexane- d_{12} ; results in the two solvents differ appreciably. Discussion of work in other laboratories referred to studies of hydrogen-bonded complexes formed by $CHCl_3$, CHF_3 , and CF_3 .

D. W. Davidson (National Research Council, Canada) treated the dielectric aspects of hydrogen bonding in solids. His talk mainly concerned recent studies of dielectric relaxation in nine forms of "ice," including the high-pressure ices of Bridgman and the clathrate hydrates. The water molecules are rotationally disordered in all of these forms with the exception of ice II. Among the other ices proper, molecules tend to reorient more readily as the density of the phase increases; this may well be associated with increasing departure from tetrahedral coordination and "weakening" of the hydrogen bonding. In the clathrate hydrates the relaxation of molecules in the water lattice is only slightly affected by the nature of the encaged molecules; the latter change from one preferred orientation to another within the cage over barriers of a few tenths of a kilocalorie per mole. Davidson suggested that the departures from simple Debye relaxation behavior noted in most "ices" are related to the presence of non-equivalent sites of water molecules in the crystals.

The symposium left the impression that although there have been no spectacular new developments in the field of hydrogen bonding since 1957 there has been much clarification of general ideas, with much new, accurate knowledge.

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Cytoplasmic Units of Inheritance

A symposium on cytoplasmic units of inheritance was held 27 December 1964 in Montreal as part of the AAAS meetings. The symposium was organized for the American Society of Naturalists.

Sam Granick, in opening the meeting, pointed out that although Mendel's classic paper was published almost 100 years ago, the science of genetics of the nucleus may be considered to have arisen at the beginning of this century when the hypothetical Mendelian factors of inheritance were found to be localized in chromosomes. These factors of inheritance, or genes, reside in the chromosomal filaments of double-stranded DNA.

During the early part of this century hypothetical factors of inheritance were ascribed also to the cytoplasm. It is only within the last few years, however, that evidence has been obtained that some of these factors of inheritance reside in filaments of double-stranded DNA in cytoplasmic organelles.

This symposium may be considered to have ushered in a new science, that of the genetics of the cytoplasm. Evidence was presented for the presence of DNA and for its coding activity in the cytoplasmic organelles of the plastids, mitochondria, centrosomes, and kinetosomes. Also, evidence was presented for a messenger-RNA molecule which replicates itself in the cytoplasm of a protozoan.

What may be the practical significance of these findings? Plant and animal breeders have been able to select appropriate nuclear genes to provide desirable characters. It may be envisioned that they will now more earnestly consider the possibilities of incorporating cytoplasmic organelles with specific properties into cells. Will it be possible, for example, to change the characteristics of a plant toward different light and temperature conditions by incorporating different kinds of chloroplasts? Similarly, will it be possible to change the rate of respiration of an animal by incorporating different kinds of mitochondria? In the case of the replicating messenger-RNA one may ask: Does this molecule of the cytoplasm, which is the simplest infectious nucleic acid known, provide a model for the origin of new disease-inducing agents?

Hewson Swift presented evidence

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