lined the way many-particle final states are studied in high-energy physics, where the proper description is of great importance, since the particles involved are usually unstable and it is only from the many-particle reactions that information on two-particle interactions can be obtained.

It is interesting to compare the methods of approach used in high-energy and nuclear physics. The aims are the same, but the types of data that can be obtained are quite different, being determined by the very different techniques that have to be used. At high energies the bubble chamber is universally used. This gives an overall picture of the reaction, however many particles are emitted. The experimenter has no choice, however, but to scan all the photographs taken to pick out the few that are of interest. With present methods the scanning and measurement of photographs is very slow, and after months of effort several tens of thousands of events may have been measured, out of which only a hundred or so may be in the kinematic configuration of major interest. An imminent breakthrough in automatic photograph analysis is, fortunately, expected. The nuclear physicist, by contrast, has no direction-sensitive detectors with good energy resolution. He has to make his counters small enough to define the direction precisely. With these small counters he can only study a minute proportion of the possible kinematic configurations needed to study a three-body reaction as a whole. Four- or more-body reactions cannot be studied because the counting-rates become too low, but they cannot be excluded and produce an unwelcome background in the energy spectra. Here, too, there is hope: one method applicable for three-body processes was described by E. Norbeck of the University of Iowa, who showed results obtained with the use of a new type of solid-state detector which is sensitive to the location at which a particle enters it.

These technical differences lead to different methods of data analysis. The high-energy physicist is forced in most cases to average his data over variables assumed not to be significant in order to obtain statistical accuracy. With the poor statistics it is impossible to test many of the assumptions. The nuclear physicist, on the other hand, has to pick out only the events he can interpret. There was discussion about whether the averaging procedure does not in some instances produce misleading results due to interference phenomena. This may be a question that can be answered more easily by a specific nuclear physics experiment designed to test it than by the laborious accumulation of sufficient data at high energies to reveal an effect which might in the end be negligible.

The unity of nuclear and high-energy physics was emphasized by the speakers. The different jargons used do, however, seem to hinder communication. For example, "overlap integral" and "coupling constant" were revealed to be essentially the same, and in a "surface interaction" one gets "peripheral production." The high point in the linguistics struggle was reached in an earlier session when a speaker unwarily spoke of a particle's being "precipitated" out of a system, and G. M. Temmer, the chairman, cautioned him to take care, "otherwise the high-energy people will call us all chemists." The nuclear physicists present were, however, delighted to hear that their favorite tools, the optical model and the distorted-wave Born approximation, are now being used in high-energy physics, while the high-energy physicists were intrigued at the enthusiasm of nuclear physicists for polology.

The final session of the conference was on few-nucleon problems. P. F. Donovan of the Bell Telephone Laboratories described some beautiful work done by a group working with the Brookhaven 60-inch (152-centimeter) cyclotron. The experimental techniques of this group are a model for all. The events recorded are displayed on a two-dimensional pulse-height analyser with oscilloscope display. The analyzer is coupled to a computer which can use any reaction theory to simulate experimental data for direct comparison with experiment on the oscilloscope. Donovan presented results on a number of reactions. Two of these stand out. In the bombardment of deuterium with deuterons there is a large peak in counting-rate for events in which the target deuteron is broken up and its neutron is left stationary in the laboratory. The shape of this peak fitted very satisfactorily with a Chew-Low dispersion theoretical analysis, probably the first really convincing fit to be obtained by this method. In the bombardments of deuterium by He^3, events were picked out in which the final state contained tritons and protons with low relative energies. The yield showed two peaks which were later shown by W. E. Meyerhof of Stanford University to be consistent with the observed cross sections for free proton-triton scattering.

The final session was further notable for the presentation by Y. Y. Yam of results obtained by a group headed by R. D. Amado at the University of Pennsylvania. This group used a high-speed computer to attack the three-nucleon problem numerically, making significant gains by writing the nucleon-nucleon potential in a convenient form. The calculations, which could not even have been considered a few years ago, gave good fits to the binding energies of H^3 and He^3 and to the neutron-deuteron and proton-deuteron low-energy scattering. This report caused a great deal of excitement, and the conference ended on a note of optimism.

The conference was sponsored by the American Physical Society in conjunction with the Oak Ridge National Laboratory and the Nuclear Structure Subcommittee of the National Science Foundation and the National Research Council. It was fascinating because almost every facet of nuclear-reaction theory was touched upon, with excursions into atomic and high-energy physics, and unusual because, while most of the participants were experimental physicists, the long discussions were mainly about theoretical nuclear physics and fundamental quantum mechanical problems. Proceedings of the conference will be published in *Reviews of Modern Physics.*

H. G. Pugh
Lawrence Radiation Laboratory, Berkeley, California

The Water Molecule in Biological Systems

The complex problem of the various forms of the water molecule as affected by the environment is approached independently by the biologist, working with complex biologic systems, and by the physicist, who uses a system of models. A synthesis of the experimental data and approaches of scientists from many disciplines, including biology and medicine, physics, chemistry, mathematics, and engineering, was the goal of the Conference on Forms of Water in

Biologic Systems, held 5–8 October 1964 under the sponsorship of the New York Academy of Sciences in collaboration with the National Aeronautics and Space Administration and the Office of Naval Research.

In the opening session the properties of water and ice were discussed by H. A. Scheraga (Cornell University), F. Franks (Bradford Institute of Technology, England), S. B. Horowitz (Albert Einstein Medical Center, Philadelphia), T. G. Owe Berg and P. R. Camp (Army Cold Regions Laboratory). Experimental data were presented which confirmed the theoretical values for the thermodynamic parameters for the formation of the hydrophobic bond. Although it is generally accepted that those nonelectrolytes (such as alcohol) which are soluble in water interact with water by hydrogen bonding, studies of the physical properties of these solutions indicate that the molecular interactions are too complex to be reconciled by simple models. A comparison of solute diffusion in cytoplasm with that in liquid water and other physical systems indicates that cytoplasmic diffusion is sensitive to, and dependent upon, the nature of the solute. At the other extreme, ice begins to form following the occurrence of nucleation, either deliberate or spontaneous, at the liquid-solid interface. The rate of growth of the initial ice sheet and the characteristics of its structure are found to depend on temperature, surface material, and crystallographic orientation of the ice.

A discussion of energy transfer in aqueous systems included papers by H. P. Schwan (University of Pennsylvania), F. Heinmets (Army Quartermaster Center, Natick), H. J. C. Berendsen (University of Gronigen, Netherlands), G. W. Gross (New Mexico Institute of Mining and Technology), and C. Jaccard (Federal Institute for Snow and Avalanche Research, Switzerland). It was shown that activation energies for proton transfer depend upon the proton concentration of ice. When the concentration of protons is high, the protons have a strong orienting effect on water. Nuclear magnetic resonance studies of a group of fibrous macromolecules (collagen, keratin, silk fibroin, for example) indicate that collagen behaves in a way different from the others with regard to rotations of the water molecule. In silk fibroin (backbone of H bonds), there are indications that at high water content the same kind of structure exists as in collagen (–NH and –C $\doteq$ O groups for binding water), but in a direction almost perpendicular to the fiber. The direct-current conductivity of ice formed in the presence of ionic impurities such as HF, HCl, KF, and NH_4F showed conductivity to be a function of the ionic species present. The inclusion of chemical impurities may modify the concentration of the different defects of the valence state and thereby alter the electric properties of ice.

The third session of the conference dealt with the physical state of water in biologic systems. G. N. Ling, session chairman, discussed the physical state of water in the living cell. Other participants were E. H. Grant (Guy's Hospital Medical School, London), N. V. B. Marsden (Uppsala University), and W. A. Senior (Unilever Research Laboratory, Cheshire, England). The spatial orientation of water molecules in the cell alters the normal freedom of motion and restricts the formation of the number of hydrogen bonds for polyhydric alcohols and hydrated ions, leading to the selective exclusion of these solutes from intracellular water. Dielectric measurements of aqueous solutions of three peptides showed that the relaxation wavelength increases with the length of the molecule; however, the activation energies are found to decrease with the size of the molecule. All activation energies can be interpreted in terms of the breaking or distorting of a hydrogen bond linking the solute molecule with its water environment. In highly cross-linked gel forms (for example, dextrans), the selectivity and interaction of molecules and ions are determined by both steric considerations and the chemical nature of the solutes. Raman properties of water reveal that the effect of hydrocarbon chains on water is to cause a shift to a higher applied field of the water proton resonance, a decrease in the spin lattice relaxation time, and an increase in the intensity of the Raman bond.

W. Drost-Hansen convened the fourth session dealing with phase transitions in biologic systems. It was demonstrated that thermal anomalies (higher-order phase transitions) occur in water and aqueous solutions, and evidence was presented to show how such anomalies may account for the existence in many biologic systems of more or less abrupt changes at a number of discrete temperatures. They may determine the existence of temperature optima, minima, and maxima for biologic activity. B. J. Luyet (American Foundation for Biologic Research, Madison) presented results which permit the construction of phase diagrams showing some of the relationships between the temperature, the concentration of the solute, and the rate of heat transfer in aqueous solutions frozen at gradually decreasing temperatures. A. P. MacKenzie, of the same institution, presented data from studies in which he attempted to clarify the dependence of freeze-drying mechanisms and of the speed at which freeze-drying occurs on the factors of molecular nature of the solute, concentration, shape and size, temperature of freezing, and partial rewarming. R. I. N. Greaves (Cambridge University) discussed the protective effects in freezing, thawing, and drying of various intracellular and extracellular additives such as dimethylsulfoxide and polyvinylpyrrolidone, respectively.

The fifth session was devoted to the problems of cellular interaction with water and ice. Participants included O. Hechter (Worcester Foundation for Experimental Biology), I. R. Fenichel (Albert Einstein Medical Center, Philadelphia), J. F. Catchpool (California Institute of Technology), D. T. Warner (Upjohn Company), and A. Leaf (Massachusetts General Hospital). A model for cytoplasmic water, viewed as a lattice-ordered matrix, was described, and its dynamics were discussed. The ordering is cooperative. The stability of the lattice depends upon the spatial array of hydrogen bonding by the individual water molecules as well as upon the stabilizing influence of protein. Interesting insights into the molecular theory of general anesthesia were provided. Support of the Pauling postulate of formation by anesthetic agents of clathrate-like structures was provided by the striking correlation between narcotizing partial pressure and the pressure necessary to cause formation of the hydrate crystals. A new concept was presented which may be the key to many polypeptide and protein molecular structures. Evidence was presented for a "hexagonal arrangement" of the carbonyl oxygen atoms in some of these compounds. The hexagonal conformation was extended to a 158–amino acid subunit of the tobacco mosaic virus, yielding a six-sided honeycomb network of 65 "cells."

The final session of formal presentations consisted of papers by R. R. Sakaida (Linde Research Laboratories), P. Mazur (Oak Ridge National Laboratory), M. Persidsky (Presbyterian Medical Center, San Francisco), P. J. Melnick (VA Hospital, Oakland), and M. J. Gonder (VA Hospital, Buffalo). This session was devoted primarily to the preservation of living systems at very low temperatures. Several concepts were presented concerning the protection of substances to be preserved by the addition of extracellular polymers such as polyvinylpyrrolidone and the optimization of procedures for bulk preservation of living materials such as blood. Interesting observations were also revealed concerning the damage inflicted upon cells subjected to sub-zero temperatures. Damage appears to be ascribable to the concentration of solutes accompanying ice formation and the formation of large intracellular ice crystals. Systematic studies of growth of ice crystals in water and in the presence of various solutes show that the rate of growth in pure water does not increase uniformly with a decrease in temperature. In aqueous solutions the rates of ice growth rise and fall considerably at certain temperatures. Enzyme activity in slowly frozen tumor tissue was either greatly diminished or stopped entirely. The activity was intense, however, when tissues were rapidly frozen to −160°C. Hydrolases and dehydrogenases behaved in this way, whereas opposite activity was noted for cytochrome-C-oxidase. Lastly, histochemical evidence was presented to show that freezing of the prostate *in situ* causes beneficial necrosis and cellular breakdown with minimal inflammatory reaction in surrounding tissue.

A masterful integration by H. Fernandez-Moran (University of Chicago) and H. S. Frank (University of Pittsburgh) of the biologic and physicochemical points of view highlighted this stimulating and provocative meeting. Following excellent summations, supported by their own laboratory data, the cochairmen were joined by the session chairman to constitute a panel for the open interdisciplinary discussion. The chemists and physicists urged the adoption of a systematic study of the water problem through the physical model system. The biologists, on the other hand, contended that the biologic system is so complex that it is not amenable to the model system and extrapolation of data therefrom. What began as discord soon took on the appearance of an attempt to understand each other's problems and an agreement for more interdisciplinary exchanges of hypotheses, avenues of approach, and aims toward multidisciplinary application. A summary can best be written by quoting an eminent participant: "Without a doubt, this meeting was one of the most fruitful and stimulating that I have ever attended. The published proceedings will rank among the classics in the field."

JOSEPH F. SAUNDERS
National Aeronautics and Space Administration, Washington, D.C.

Communications in Unusual Media

Recent advances in unusual communications techniques were brought to the attention of the scientific community at the session on Communications in Unusual Media of the Northeast Electronics Research Meeting (NEREM), held in Boston on 4 November 1964.

In the opening paper K. Powers of R.C.A. Laboratories discussed the possibilities for long-range seismic communications. A convincing presentation was made describing seismic modes which appear to permit communications over thousands of kilometers. Powers based his arguments on data recorded during United States underground nuclear detonations. Because the gradient of velocity increases with depth in the earth, seismic wave fronts of nearly vertical incidence into the ground bend upwards to arrive back at the surface at some distance from the source. Work of the seismologist B. Gutenberg has shown the existence of a "low-velocity layer" or negative gradient layer about 80 km below the continental crust. As a ray hits the low-velocity layer with near grazing incidence, the negative gradient tends to bend the wave downward until the layer of positive gradient reverses the direction of the ray. This layer thus produces a shadow zone but, more importantly, provides a wavelength in which seismic waves can be trapped and can travel with low attenuation to great distances.

Although the propagation characteristics of the lower layer have not been completely established, seismological data from underground nuclear explosions lend support to the hypothesis advanced by Gutenberg. During 1958, a network of seismic recording stations was set up to observe seismic waves resulting from the Blanca underground explosion. The network provided observations from ground zero out to a range of 4000 km. At close range and out to a distance (d) of about 500 km, straight spreading in which the amplitude is proportional to $1/d^3$ was noted. However, the magnitude in the vicinity of 1000 km is seen to be somewhat below the level that would be expected for the normal compressional-wave mode. It is suspected that these seismic stations were in the "shadow zone." At distances beyond 1000 km, the amplitude was found to be considerably higher than one would expect from normal ray theory and could be explained only in terms of channelized or waveguide mode propagation. In addition, there appeared to be no significant loss due to attenuation between 1500 and 4000 km. The predominant period of the waves observed at the greater distances was about 1 second or slightly less.

For communication purposes, the explosions must be replaced by coherent waveform generators—for example, the hydraulic shakers that are used in oil exploration. Although only 5 percent of the seismic energy produced by such a shaker results in compressional waves, the compressional-wave content can be increased by the use of a phased array.

Since most of the high-attenuation mode conversion and multipath phenomenon characteristic of seismic propagation actually takes place in the 30-km deep crustal layers of the continents, it would be advantageous to place both transmitter and receiver as deep as possible in the ground—for example, in abandoned mine shafts. Such placement would not only have the advantage of obtaining a more direct coupling to the earth's mantle and reducing the generation of surface waves, but the microseism noise at the receiving site would also be low. Under these conditions, a means of communication between deep holes in the ground on the east and west coasts of the United States, which would transmit data at a rate of approximately 1 bit per second, may be possible.

The second paper, concerning radio propagation through the earth's crust, was presented by J. deBettencourt and C. Tsao of the Raytheon Company. In