to open entirely new vistas in biology. They suggest a method by which matter can be made; and they offer, or seem to offer, an escape from the purely mechanistic theories of conduct and life. It would take much longer, however, to consider these revolutionary conceptions than we have time for to-night; and I will only call your attention to them in passing. Those of us who are alive twenty years from now will probably in that time have passed through a revolution of biological thought as great as any the world has ever seen. And this revolution will unquestion ably have important consequences for the physician and his patient.

I have by no means exhausted the applications of physical chemistry to medicine. In fact, I have mentioned only a very few which have particularly interested me. But I shall have compassion on you and stop with these.

I believe and hope that the development in our knowledge of energy and matter and vitality, developments which are impending, will stimulate above all the science of therapeutics, that step-child Cinderella, at present hardly tolerated, and boxed about most unkindly, to our great disgrace, in every American medical school. I believe physical chemistry, or physics with chemistry, is spinning for her a new dress, a dress shining and splendid. Once bedight in it she will dazzle the eye and warm the heart of even the oldest, most experienced and most cynical among us, and be seen for what she is, the fairest daughter among the medical sciences. And I venture to say that in no way can the science of physical chemistry serve medicine better, playing the rôle of Prince Charming, than by leading this Cinderella from her position of drudge to the throne of medicine.

For it is the neglect of therapeutics, which is, I believe, one of the most serious shortcomings of present-day medicine. And it is in this field that physical chemistry can contribute most.

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THE ABUSE OF WATER[1]

IT would appear obvious that the fundamental principles of science must not be dependent upon any casual feature, such as environment. Thus the laws of gravitation should be just as rigid on the sun or the moon as on the earth. In a science which is mainly experimental, also, such as chemistry, it would seem to be a simple matter to insure that the results of experiments were not being misinterpreted due to their environment. This might be done either by changing the conditions under which the experiments were being conducted, or by a rigorous study of the existent conditions and of their possible influence. Nevertheless, the history of chemistry affords numerous instances where whole schools of investigators have gone astray through neglect of such precautions.

A noteworthy example is given by the famous phlogiston theory, which predicated that substances which were changed by heat did so through loss of phlogiston. We now know that such substances are actually changed through combination with the oxygen of the air in which they are heated, but this explanation did not secure acceptance until the nature and properties of oxygen had been thoroughly investigated and until the effect of heating substances in the absence of oxygen had been noted. At the present time, we still allow our oxygen environment to influence our definitions to some extent. We call a body "combustible" if it burns in the air, and "non-combustible" if it does not. That such terms have no strict scientific meaning is evident if we imagine ourselves to be translated, for a moment, to a world in which the atmosphere contained hydrogen as an active component instead of oxygen. In such a world fires would be extinguished by sprinkling gasoline on them, and non-inflammable buildings would consist of solid paraffin.

The modern science of physical chemistry has been almost wholly developed through the study of very dilute aqueous solutions, and a scrutiny of this water environment suffices to show us that our present viewpoint is considerably distorted and incomplete in many respects. Water itself is almost as much a mystery to the chemist of to-day as oxygen was to Priestley. We call it H_2O in the text-books, but liquid water certainly does not consist of simple molecules of H_2O. What the actual complexes are, and how they are changed on addition of a solute, are points on which we are entirely ignorant. The theory of dilute solutions founded by van't Hoff avoids the difficulty by assuming that we may regard the solute as existent in the gaseous state, neglecting the water absolutely as so much "dead space." This idea, though still popular in the classroom, has been shown by the more modern theory of ideal solutions to be quite erroneous. There is no direct analogy between solutions and gases; a substance such as sugar, when dissolved in liquid water, is not in the gaseous state but in the liquid. In a liquid solvent, solution and fusion are identical terms; sugar melts in hot tea just as ice melts in iced tea. The two components of a solution, solvent and solute, must be considered as equally important, but at present our procedure is to let familiarity breed contempt and to

[1] Abstract of an address delivered before the Institute of Chemistry of the American Chemical Society, State College, Pa., July 28, 1927.

ignore the water altogether. Consequently the identity of freezing-point depression and solubility laws is seldom made apparent to the student; he is taught the same fact twice under two different names.

When hydrogen chloride HCl is dissolved in water H_2O, two substances which do not conduct the electric current separately give a solution which is an excellent conductor. We "explain" this by assuming that the hydrogen chloride HCl is split up, or ionized, into positively charged H^+ and negatively charged Cl^-, and that the migration of those ions towards the electrodes accounts for the conductance. Why, in a mixture of HCl and HOH, two substances with perfectly similar characteristics, should one be active and the other quite inert? Simply because we are so familiar with water (or think we are) that we do not trouble to take it into consideration. Suppose we lived in a world in which another liquid, say sulphuric acid, was the familiar reference liquid, and suppose that in this world an ingenious chemist discovered a hitherto unknown substance, water. He would put a little of it into the practically non-conducting solvent, 100 per cent. H_2SO_4, and would decide that the solution was an excellent conductor. This would apparently justify the announcement in the scientific press that the new compound HOH was highly ionized in a solution—a typical strong electrolyte—a very polar substance—almost completely broken up into H^+ and OH^-. Yet the chemists of another world, in which acetic acid was the reference liquid, would agree that water was a weak electrolyte, and those of a third world, in which ethyl alcohol was supreme, would call it a non-electrolyte.

Evidently, to develop a consistent theory of conducting solutions, we have again to insist on the equality of solvent and solute. We can not obtain a true conception of ionization, either by the classical theory of Arrhenius or by the more recent theory of Debye, unless we consider the two components of a conducting solution impartially. A theory of ionization has been presented by Werner, indeed, which goes to the opposite extreme, regarding water as the *only* substance which ionizes directly in aqueous solution. This theory is just as good as the currently accepted view, and leads to the same mathematical conclusions.

That the study of systems in a non-aqueous environment will certainly develop results of great significance in chemistry has been shown by the excellent work of Franklin and his coworkers on reactions in liquid ammonia. That the closer study of water itself will open up new avenues of advance has been clearly indicated by the remarkable work of Baker on systems from which the last minute traces of water have been removed. Instead of being a substance which can be neglected, water is perhaps the most reactive of all substances. When we cease to abuse it and recognize its proper importance, a new and more general chemistry of solutions will be born.

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FRANK W. VERY

WITH the death of Frank Washington Very on November 23, 1927, there ended the earthly career of an active investigator in the fields of astrophysics, meteorology and aerodynamics. Born in Salem, Mass., in 1852, the son of Washington and Martha (Leach) Very, he specialized in chemistry at the Massachusetts Institute of Technology and received his degree of bachelor of science there in 1873. He entered the field of astronomy and became first assistant at the Allegheny Observatory, 1878–1895, under the direction of Dr. S. P. Langley; was professor of astronomy at Western University, Pennsylvania, 1890–1895, and director of Ladd Observatory of Brown University, 1896–1897. Afterward he was engaged in researches on astrophysics and other allied sciences at Westwood, Mass. In 1893 he married Portia Mary Vickers, of Glenshaw, Pa., and there survive five children, Arthur, Ronald, Mrs. E. R. Brown, Mrs. A. C. Bartlett and Miss Marjorie Very. Very was a pioneer in several fields of science and loved the work of the pioneer.

He was a man of great originality and had an intense enthusiasm in the pursuit of knowledge. His activities in science covered a wide range of subjects. He assisted Langley for ten years in his epoch-making work in astronomy and in the aerodynamic studies on which Langley based his model flying machine weighing 25 pounds which successfully flew over the waters of the Potomac. He assisted Frank W. Bigelow in the preparation of his books on the thermodynamics of the atmosphere and cooperated with Percival Lowell in his studies of the atmospheres of the planets. In 1900 he was at work with radio experts in devising a system of signals for our weather bureau by means of which information from vessels at sea might be received by radio then in its early stages. He also assisted Dr. Williams in the study of the application of X-rays to medical practice. At the same time he was carrying on a large amount of original work on his own account. Probably his greatest contributions to science were his studies of the moon's surface temperature and his studies of the absorption of heat by our atmosphere, each of which filled a large volume when published. The last was published as "Bulletin G" by the United States Weather Bureau in 1900. By ingenious methods he