ON THE PHYSIOLOGICAL EFFECTS OF RADIO WAVES[1]

THE statement is common that only living material is heated when exposed to short radio waves. It is shown to be erroneous by the observations of Hosmer and McLennan, but because it persists we conducted a series of experiments of our own. To this end we subjected a series of simple solutions to high frequency currents.

Concentrated solutions of various electrolytes, such as potassium chloride, barium chloride, acetic acid, sulfuric acid and sodium hydroxide were found to be slightly heated, but the intensity of this heating increased with dilution to a maximum, decreasing with still further dilution. The amount of heating was found not to be the same for a given concentration of different substances, or a function of the concentration of a given electrolyte, varying, rather, with its specific electrical conductivity. Thus, normal acetic acid, having a higher resistance, was heated more than normal sulfuric acid. Such effects are reported by Helen Hosmer[2] and by J. C. McLennan and A. C. Burton[3] and our own observations are offered as a confirmation of their work.

It has also been reported that egg white and sugar solutions are heated, and that gelatine becomes warm and finally liquefies when irradiated by short electromagnetic waves. No proof has been offered to show that such heating is not due to contaminating electrolytes, for it is impossible to remove traces of salt from egg-white or gelatine without altering the proteins profoundly. But dextrose, as an example of a non-electrolyte, is obtainable in pure form by recrystallization of the material from syrup through the addition of alcohol. We found dilute solutions of such purified dextrose not to be heated by high frequency currents. When our concentrated syrups did show a slight elevation of temperature we felt that it was due to contamination with electrolytes from the containers, etc. A sample of twice distilled (crystalline) phenol was partly liquefied when irradiated, but a thermometer fixed in the mass recorded no change in temperature. Neither did solutions of low concentrations of water dissolved in the phenol or of phenol dissolved in water show temperature increases. A solution of dry hydrogen chloride in benzene remained unheated.

We feel that these findings have a bearing upon the explanation of what happens in the therapeutic use of high frequency currents in paresis and other clinical states, as well as in the studies that have been made on the selective effect of such waves on different tissues by J. W. Schereschewsky and H. B. Andervont[4] and J. C. McLennan and A. C. Burton.[5] Schereschewsky irradiated animals bearing transplantable mouse or fowl sarcoma and reported recessions in the growth of the tumors. We feel that the explanation of the selective effects is dependent upon the fact that neoplastic, "inflamed" or "injured" tissues are richer in water than normal tissues. They represent a shift in the protoplasmic system from a "dry" hydrate toward a better solution of the constituents of protoplasm in water and are therefore peculiarly sensitive to the action of radio waves. The shift, in other words, makes a better solution of electrolytes in water and is analogous to the change which is suffered by a soap or proteinate solution when heated or diluted, thereby suffering a change from what was originally a solution of water in the soap or protein to one of the soap or protein in water. A distinguishing characteristic of neoplastic growth is its ability to liquefy its medium and thus to continue its growth. Chicken sarcoma transplanted to a clot of blood plasma, for example, liquefies it within a few hours, and, unlike normal cells, divides in this liquid medium. Pathogenic bacteria evidence the same reaction when grown upon gelatine or when they produce the edema which they evoke in living matter. The liquefaction in both cases is a general reaction representing transition of a concentrated mixture of protein and salts in a water-poor medium toward a dilute solution of these salts and protein in a larger amount of water, the intermediate edema representing the incomplete middle phase in the total reaction. Just as concentrated solutions are little heated by electromagnetic waves while more dilute ones are better heated, even so will a neoplasm bathed in a dilute and salt-containing solution of protein, or the more highly hydrated, soluble and edematous infected tissue be more strongly affected (heated) by such waves than the more normal, "concentrated" and water-poor tissues.

JOSEPH L. DONNELLY

LABORATORY OF PHYSIOLOGY,
UNIVERSITY OF CINCINNATI

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[2] Helen Hosmer, SCIENCE, 68: 325, 1928.

[3] J. C. McLennan and A. C. Burton, *Canadian Journal of Research*, 3: 224, 1930.

[4] J. W. Schereschewsky and H. B. Andervont, *Public Health Reports*, 43: 927.

[5] J. C. McLennan and A. C. Burton, *Canadian Journal of Research*, 5: 550, 1931.

BOOKS RECEIVED

Mededeelingen en Verhandelingen. Het Klimaat van Nederland. 34a. Pp. 101. Illustrated. Koninkliijk Nederlandsch Meteorologisch Instituut, De Bilt, Holland.

Republica Argentina, Boletin Mensual del Ministerio de Agricultura de la Nacion. Tomo XXXII, No. 3. Pp. 397–623. Illustrated. Seccion Propaganda, Publicaciones, Concursos y Exposiciones, Buenos Aires.

WILLCOX, WALTER F. *Introduction to the Vital Statistics of the United States, 1900 to 1930.* Pp. v+138. U. S. Government Printing Office.