Final Report
on Work Done Under Contract Nonr-2437(00) on
ICE FORMATION IN AQUEOUS MEDIA OF BIOLOGICAL INTEREST

B. J. Luyet
American Foundation for Biological Research, Madison, Wis.

This program deals, on the whole, with the changes which take place in aqueous media, mostly solutions, when their temperature is lowered and raised at various rates to various end points. Particular emphasis is placed on the effects of rapid cooling to very low temperatures in conditions under which a stable equilibrium cannot be reached, and on the effects of a relatively slow rewarming during which the equilibrium is reestablished. The information obtained can be classified into three categories: (1) methods, (2) changes observed, (3) special problems; these are presented in three sections in the table of contents below.

The findings were published in 9 papers (some 125 pages) and in 7 abstracts of communications made at meetings of the Society for Cryobiology, the Biophysical Society and the American Physiological Society. The papers (numbered 1 to 9) and the abstracts (numbered A1 to A7) are listed hereafter and the subject-matter treated is indicated in the table of contents by the numbers in the columns on the right side.

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The program of the research reported here emphasized the importance of the cooling rates in the preservation of biological material in the frozen state (such as would be the case, for example, in the preservation of blood).—The cooling rates obtained by immersion of specimens in various refrigerants, including liquid nitrogen under pressure or at its freezing point, and liquid helium II, were measured. The method of increasing the rate of cooling of an object immersed in a boiling refrigerant by coating the object with a vapor-nucleating substance was investigated; in some cases the rate could be increased 23 times.—The study of the structural instability and molecular mobility in rapidly cooled aqueous solutions which are partly crystalline and partly amorphous furnished information on changes occurring at the temperatures of (a) the "glass transition", (b) devitrification, (c) recrystallization (of which 4 kinds were distinguished), and (d) eutectic melting. These changes were investigated by various methods, in particular, dilatometry, calorimetry and X-ray diffraction.—Tentative applications of our basic studies to biological materials included determinations of the water-binding capacity of the tissues of hibernating animals.
Low temperature, ice, freezing, crystallization, recrystallization, vitrification, devitrification, glass transition, eutectic, cooling rates, freezing rates; aqueous solutions, water binding, instability of frozen solutions; X-ray diffraction, dilatometry; temperature biology, cryobiology, cryopreservation, cryoprotective agents; hibernating animals, blood clotting.