

BEST AVAILABLE COPY

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.

02  
83

AD 651765

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.

Table of Contents:	Papers:	Abstracts:
1. Methods for obtaining rapid cooling and for determining cooling rates; rates actually obtained	2	A2,A3 A4,A6
2. Changes encountered when aqueous solutions are cooled and rewarmed at various rates		
(a) Nucleation		A5
(b) Vitrification and glass transition	6,7,8	
(c) Amounts of ice formed		A7
(d) Recrystallization	1,5	
(e) Eutectic melting		A1
(f) Miscellaneous transitions	3,5	
3. Special problems: state of water in tissues of hibernators and role of magnesium in their blood	4,9	

20040903000

STATEMENT NO. 1

(Page 1)

Distribution of This Document is Unlimited





(A2) B. Luyet and C. Kroener. The Highest Obtainable Cooling Velocities. Abstract L7, Fourth Annual Meeting of the Biophysical Society, February 24-26, 1960, Philadelphia, Pennsylvania.

(A3) B. Luyet. Toward Higher Freezing Rates. Abstract SE6, Fifth Annual Meeting of the Biophysical Society, February 16-18, 1961, St. Louis, Missouri.

(A4) A. P. MacKenzie, L. W. Evers and B. J. Luyet. Effects of the Thickness of an Insulating Coat on the Cooling Velocity of Heat-Conductive Objects Immersed in Liquid Nitrogen. Abstract TCS, Sixth Annual Meeting of the Biophysical Society, February 14-16, 1962, Washington, D. C.

(A5) B. J. Luyet and C. Kroener. Grain Size in Blood Plasma Frozen under Various Conditions. Abstract No. 6, Second Annual Meeting of Soc. for Cryobiol., Madison, Wisconsin, Aug. 2-4, 1965. Cryobiology, 2, p. 8.

(A6) A. P. MacKenzie, C. Kroener and B. J. Luyet. Rapid Cooling by Means of Pressurized Liquid Nitrogen. Abstract No. 26, Second Annual Meeting of Soc. for Cryobiol., Madison, Wisconsin, Aug. 2-4, 1965. Cryobiology, 2, p. 17.

(A7) C. Kroener and B. J. Luyet. Determination of the Heat Released in the Rewarming of Rapidly Cooled Solutions of Polyvinylpyrrolidone. Abstract No. 40, Second Annual Meeting of the Soc. for Cryobiol., Madison, Wisconsin, Aug. 2-4, 1965. Cryobiology, 2, p. 22.

Security Classification

**DOCUMENT CONTROL DATA - R & D**

*(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified.)*

1. ORIGINATING ACTIVITY (Corporate author) American Foundation for Biol. Research Box 54, RFD 1 Madison, Wisconsin 53716		2a. REPORT SECURITY CLASSIFICATION	
		2b. GROUP	
3. REPORT TITLE Ice Formation in Aqueous Media of Biological Interest			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Final Report			
5. AUTHOR(S) (First name, middle initial, last name) Basile J. Luyet, Calvin Kroener, Gabriel L. Rapatz, Alan P. MacKenzie, J. Tanner, R. Masat, L. W. Evers			
6. REPORT DATE May, 1967	7a. TOTAL NO. OF PAGES 5	7b. NO. OF REFS 16	
7c. CONTRACT OR GRANT NO. Nonr-2437(00)	8a. ORIGINATOR'S REPORT NUMBER(S) ONR 2437-F		
8. PROJECT NO. NR 108695	9. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)		
10. DISTRIBUTION STATEMENT Unlimited distribution			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY ONR	
13. ABSTRACT 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.			

Security Classification

14. KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
<p>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.</p>						