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Fate of Blood Sugar During Glycolysis.

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A review of the literature on glycolysis warrants the conclusion that the sugar of shed blood diminishes on standing, independent of bacterial contamination. With respect to the fate of the lost sugar, several papers have been reported in the literature, deducing somewhat similar conclusions, that a portion of the lost sugar is converted into lactic acid. However, there remained the uncertainty as to the quantitative relation of the sugar lost to the amount of lactic acid produced.

In order to clear up this point, we carefully studied the blood glycolysis *in vitro* from the point of view of the simultaneous changes taking place in the glucose and lactic acid contents of the blood.

The blood was drawn in all instances from the veins under aseptic conditions and maintained at 38° C. free from bacterial contamination. Analyses of the blood were made immediately and after 3, 6 and 24 hours. Potassium oxalate was employed as an anti-coagulant for the whole blood. The amount of the potassium oxalate used was roughly 0.06% of the blood. The specimen was cultured at the end of 24 hours and thus bacterial contamination was excluded.

Analytical Procedures: Brehme and Brahdý¹ have recently described a comparatively simple and accurate method for the estimation of the lactic acid of blood. Hence we employed their method for the determination of lactic acid in the blood. The sugar of blood we determined by the Shaffer-Hartmann method.²

Discussion of Results: The results are presented in Table I. The findings for 10 subjects showed that the *in vitro* process of glycolysis, the sugar gradually decreases with a parallel rise in the lactic acid. All instances except one (subject 2) showed that the difference between the amount of disappeared sugar and the increased lactic acid during 24 hours lies within 12 mg. In subject 2 the difference between these 2 substances was 20.5 mg.

¹ Brehme, T., and Brahdý, B., *Biochem. Z.*, 1926, **clxxv**, 348.

² Shaffer, P. A., and Hartmann, A. F., *J. Biol. Chem.*, 1921, **xlv**, 365.

TABLE I.
Glycolysis and Production of Lactic Acid of Blood.

Case	Age	Sex	Test Hour	Sugar	Lactic Acid	Lost Sugar	Gained Lactic Acid	Difference Sugar-Lactic Acid
				mg. per 100 cc.		mg. per 100 cc.		
1	35	M	At once	92	24.6			
			3 hrs.	74	46.0	18	21.4	— 3.4
			6 hrs.	74	59.2	18	35.6	—17.6
			24 hrs.	18	107.7	74	83.1	— 9.1
2	28	F	At once	109	22.7			
			3 hrs.	92	47.3	17	24.6	— 7.6
			6 hrs.	66	59.2	43	37.5	+ 5.5
			24 hrs.	18	93.2	91	70.5	+20.5
3	20	M	At once	99	22.1			
			3 hrs.	76	40.3	23	18.2	+ 4.8
			6 hrs.	66	55.4	33	33.3	— 0.3
			24 hrs.	18	91.9	81	69.8	+11.2
4	25	M	At once	122	18.3			
			3 hrs.	89	39.7	33	21.4	+11.6
			6 hrs.	66	55.4	56	37.1	+18.9
			24 hrs.	25	105.8	97	87.5	+ 9.5
5	32	M	At once	154	19.5			
			3 hrs.	129	32.8	25	13.3	+11.7
			6 hrs.	114	46.0	40	26.5	+13.5
			24 hrs.	99	82.5	55	63.0	— 8.0
6	41	F	At once	119	18.3			
			3 hrs.	104	30.9	15	12.6	+ 2.4
			6 hrs.	87	43.5	32	25.2	+ 6.8
			24 hrs.	39	95.8	80	77.5	+ 2.5
7	36	M	At once	114	16.4			
			3 hrs.	92	32.8	22	16.4	+ 5.6
			6 hrs.	76	41.6	38	25.2	+12.8
			24 hrs.	28	93.2	86	76.8	+ 9.2
8	21	F	At once	111	15.8			
			3 hrs.	89	30.9	22	15.1	+ 6.9
			24 hrs.	39	83.1	72	67.3	+ 4.7
9	13	M	At once	95	24.6			
			3 hrs.	66	51.0	29	26.4	+ 2.6
			24 hrs.	14	105.2	81	80.6	+ 0.4
10	12	M	At once	92	22.7			
			3 hrs.	66	47.9	26	25.2	+ 0.8
			6 hrs.	36	62.4	56	39.7	+16.3
			24 hrs.	5	104.7	87	82.0	+ 5.0

Levene and Meyer³ have shown that when leucocytes were suspended in Henderson's phosphate solutions containing glucose, a portion of the glucose, as such, disappeared with the production of lactic acid. Evans⁴ has observed a fall in the carbon dioxide capacity of shed blood which, he believes, is due to a conversion of glucose into lactic acid as a result of glycolysis. Kraske⁵ in his studies on 7 human subjects reported a quantitative conversion of the lost

³ Levene, P. A., and Meyer, G. M., *J. Biol. Chem.*, 1912, xi, 361.

⁴ Evans, C. L., *J. Physiol.*, 1922, lvi, 146.

⁵ Kraske, B., *Biochem. Z.*, 1912, xlv, 81.

blood sugar into lactic acid during an incubation of 2 hours. Kondo,⁶ however, in his experiments on glycolysis in dog's blood during a similar period of incubation found that the increase in lactic acid was much less than the amount of sugar lost. Morgulis and Berkus⁷ have reported that the disappearance of the sugar proceeds parallel with a formation of lactic acid. Their figures, however, do not demonstrate this parallelism. Katayama⁸ failed to find a production of carbon dioxide as a result of glycolysis.

None of the observers in the literature did demonstrate substances other than lactic acid produced as a result of glycolysis. In our experiments we confirmed the quantitative recovery of lactic acid from the blood sugar during glycolysis.

Summary: The sugar of shed blood gradually decreases on standing without bacterial contamination. The disappearance of the blood sugar is accounted for by the formation of a corresponding amount of lactic acid.

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Reversible Changes in Living Protoplasm.

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It has been shown¹ that when a cell of *Nitella* is cut a wave of some sort, which we may for convenience call a death wave, passes rapidly along the cell and that at each spot it reaches a characteristic death process is brought about. In dilute solutions (*e. g.* 0.001 M KCl) this consists of a sudden change whereby the protoplasm becomes more negative after which its potential difference approaches zero.

These alterations are irreversible but similar changes of a reversible character may occur spontaneously or may be induced by a variety of reagents (both organic and inorganic). After the removal of the reagents the changes often cease at once or after some minutes. Very often these changes are rhythmical and appear to travel along the cell, sometimes at a high rate of speed.

⁶ Kondo, K., *Biochem. Z.*, 1912, xlv, 88.

⁷ Morgulis, S., and Berkus, O., *J. Biol. Chem.*, 1925, lxxv, 1.

⁸ Katayama, I., *J. Lab. and Clin. Med.*, 1926, xii, 239.

¹ Osterhout, W. J. V., and Harris, E. S., *J. Gen. Physiol.*, 1928-29, xii, 167.