

THE EFFECT OF VELOCITY ON DIFFUSION RATES.—By A. E. MURRAY, B.A., Pharmacological Department, Dalhousie University, Halifax, N. S.

(Presented 14 November 1928)

ABSTRACT.

Experiments have been conducted by placing salt solutions in colloidin thimbles and allowing them to diffuse into distilled water which was either circulated or being constantly replaced.

Under such conditions there is a rapid development of a small osmotic pressure which was measured directly by a capillary tube reading. This rise, usually complete in 60-90 minutes, was shown to be influenced by a velocity of the diffusate, though not proportionally in the case of NaCl. A rough relation was found in the case of 1% disodium phosphate.

Introduction: It is generally conceded that if a salt diffuses readily through a permeable membrane that its osmotic effect from a physiological point of view is negligible. Indeed with such authors as Bayliss¹ or Burns² the question of temporary osmotic pressure, such as is developed by sodium chloride diffusing against distilled water through colloidin membranes, is not mentioned; also in the filtration part of renal function it is assumed that the only effective osmotic of the blood is that due to the colloids. If however the pressure of blood be directly measured by means of colloidin filters then it is necessary to wait twenty-four hours until an equilibrium be obtained owing to the salts effecting a temporary osmotic pressure.

In view of these facts it appears possible that the diffusible salts might play an important osmotic role in the body since the circulation may either prevent a diffusion equilibrium from becoming completed by removing a substance faster than it diffused, or by itself creating disequilibrium. In such places where rapid metabolic breakdown was occurring this especially appears possible.

1. Bayliss, W. M., Principles of General Physiology, Longmans, Green & Co.

2. Burns, D., An Introduction to Biophysics, J. & A. Churchill.

Experiments have therefore been conducted to ascertain if velocity will effect changes in the osmotic pressure rise of various salts diffused into distilled water. These experiments roughly consisted of placing a salt solution in a colloidin thimble which is surrounded by distilled water, the osmotic pressure rise being measured directly by the column developed in a capillary tube. Arrangements were made either to circulate the fluid past the membrane or to pass a continuous stream of fresh water over the membrane.

Preliminary experiments were carried out with a motor driven pump giving a varying circulation rate of 400 to 2000 cc per minute. The flow was recorded by a venturiometer, which of course required calibration. Various speeds at room temperature were employed, using a total volume of 100 cc. of circulating fluid (distilled water) against 5 cc. of 1% NaCl. Compared to zero reading—see Table I below—it was clear that moving the fluid increased the height of pressure rise, but all the velocities used seemed to have approximately the same effect.

These results suggested that the circulatory rate was too high, consequently this was reduced. This was accomplished by the use of an apparatus described by Gibbs³ for measuring blood flow. By a slight alteration this instrument can be made to pump at a definite rate controlled by a time clock. (see Table II). No great differences were achieved. This suggested that the method was so crude that small differences would not appear. The effect of temperature on the curve was studied, since it became obvious that this was upsetting some of the results. The difference between room temperature (an approximately body temperature) is to increase the osmotic rise slightly. Thereafter work was carried on at this temperature controlled in a water bath.

So far the experiments had not brought to light any marked change. Instead therefore of merely circulating the fluid the apparatus was arranged to pump fluid past the mem-

3. Gibbs, O. S., A New Method of Measuring Blood Flow., Transaction of the N. S. Institute of Science. 1928.

brane at a given speed. This resulted in a greater rise, but again no proportion was proven.

Experiments were then conducted on the permeability of the membranes. These experiments showed that permeability changes caused marked alteration of the osmotic rise. They further emphasized that the errors which were constantly appearing were in all probability associated with changes in the permeability of the membranes as yet uncontrolled. Before however taking up this problem in detail other salts were investigated, and it was found that a velocity effect could be demonstrated on 1% disodium hydrogen phosphate as the accompanying Table III shows.

TABLES.

	Velocity cc. per minute	Time taken minutes	Total rise cms.
Table I.	0	110	9
	400	75	15
	570	70	14
	800	75	16
	1466	75	24
	1600	60	17
Table II.	5	110	20
	8	110	19
	12	110	19
	36	95	22
Table III.	1.5	90	35
	6	90	49
	18	58	52
	36	67	67

Thus the fact becomes established that the velocity of the surrounding fluid may alter the temporary osmotic pressure developed by salt against water. Direct measurements on the actual diffusion rate of the salt have not been carried out, but it would appear that this also is altered. These results natu-

rally suggest the importance of the blood flow on the absorption of substances in the tissues spaces, as well as their diffusion outwards.

The results obtained are not sufficiently accurate to warrant mathematical analysis. It is hoped however to repeat them, using more accurate methods which will involve most careful standardization of the membranes. Some of the results suggested—that a membrane alters its permeability on use, the cause at present being unknown, through accidental contamination is one possible source of error.

Summary.

1. It has been shown that the osmotic pressure rise developed by salt diffusing against distilled water is influenced by moving or changing the diffusate.
2. A rough relationship has been shown between the pressure rise and the velocity when 1% Na_2PO is diffused against distilled water.

This work was aided by a grant from the National Research Council.