MURRAY, M. 1925.

THE ABSORPTION OF ALCOHOL IN THE STOMACH AND SMALL INTESTINE, AND THE EFFECT OF CO_2 THEREON.

Although there have been extensive researches, notably by Pavlov, Edkins, and numerous American and Edinburgh workers, on the secretory functions of the stomach, it has remained somewhat doubtful from their work whether a neutral liquid such as Ringer's solution would cause secretion of gastric juice in an animal in which the vagi had been destroyed by oesophageal ligature.

Edkins performed his "acute experiments" on anaesthetised animals and found that neither water nor saline were absorbed or caused any appreciable secretion of acid. This might also be true of the normal animal, but it is scarcely permissible to deduce this fact from the experiments of Edkins when anaesthetics are known to alter secretory activity in a very marked degree.

For all the experiments performed in the course of the investigations which are to be described, decerebrate or pithed animals were used. In this way it was anticipated that a more normal condition of the secretory activity of the mucous membrane would be attained.

This study of secretory activity was however not the initial object of the experiments. Originally it was intended to investigate the limits of the absorption of certain solutions through the gastric mucous membrane. In "acute experiments" reliance had hitherto beenplaced on anaesthetised animals. It is permissible to regard the stomach as predominantly a

secretory structure, its function as regards absorption being secondary. It is known however that alcohol, and certain other drugs, may be absorbed by the stomach.

A good deal of work has been done on the absorption of alcohol into the blood from the alimentary canal in the normal animal under varying conditions, but the degree of absorption that took place in the stomach could not be determined in this way.

In many of the recorded experiments very high concentrations of alcohol have been used and such as man would never have to deal with in ordinary life. These high concentrations of alcohol in the stomach were avoided in the present experiments as likely to promote too abnormal a state.

It is an ordinary experience that alcoholic beverages taken with aerated waters produce their characteristic effects much more rapidly than when taken in ordinary water. The scientific basis of this fact was investigated by experiments on the effect produced on the absorption of alcohol by the presence of CO_2. Later some of these investigations were extended to the intestinal mucous membrane.

The work to be described falls into two main divisions. In Part I. the points studied were (a) the degree of absorption of physiologically inactive liquids, and (b) the secretion of hydrochloric acid as indicating the secretory activity which these liquids caused. In Part II. the absorption of alcohol and the effect of CO_2 on the amount of absorption was considered.

Throughout the experiments great care was taken to keep the animals as nearly normal as possible in order that the deductions made from the results might be physiologically sound.

PART I.

METHOD.

All the experiments were performed on cats. The animals wherever possible were kept in the laboratory for several days preceding the experiment and during that time fed on lean meat in order that the alimentary canal might be in a good condition.

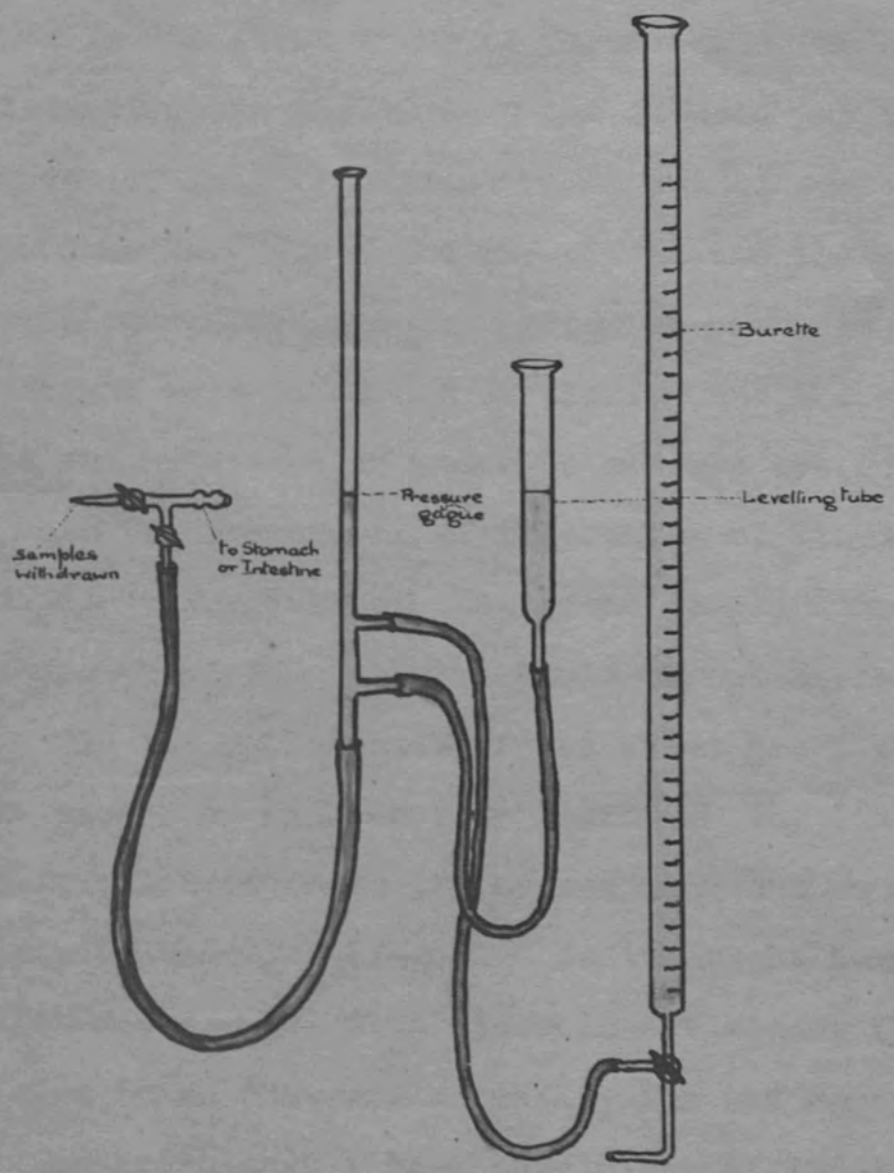
In the early experiments the animals were first anaesthetised with chloroform but later ether was used as it was found that with ether the blood supply to the stomach was much better. This preliminary anaesthesia was for the purpose of preparing the animal for decerebration or pithing.

After the preliminary anaesthesia the animals were placed in a normal saline bath kept constant at 37°C so as to eliminate shock as far as possible when the abdomen was opened.

Tracheotomy was performed, the central end of the carotids tied and the animals decerebrated or pithed by Langley's method; injection of 10% starch suspension in 7% gum Ringer.* As soon as respiration ceased the trachea was connected with the artificial respiration pump. Then the abdomen was opened, a tight ligature tied round the oesophagus, great care being taken not to include obvious blood vessels. The intestine was then clipped off with Spencer-Wells forceps, an incision made across the duodenum about a centimetre below the pylorus and the stomach well washed out with several injections of warm saline. A T-shaped tube with a tap on one limb was then tied into the opening.

*It was found early in the investigation that there was greatly improved permanence of the suspension of starch when gum was added to the Ringer.

APPARATUS FOR INTRODUCTION AND MAINTENANCE OF LIQUID AT CONSTANT PRESSURE



The liquids placed in the stomach were introduced at a low pressure and during the whole time kept at a pressure within the stomach of 5 cm. of water.

In the first group of experiments the apparatus used for introducing the liquid into the stomach was similar to that previously used by Edkins. The animal was connected with the apparatus throughout the experiment and the total amount of liquid introduced noted. After an hour, two measured samples of liquid were withdrawn at the tap and the rest drawn back into the apparatus in order to measure the volume recovered. In this way the amount of absorption of liquid could be measured. Further by analysis of the second sample withdrawn by the tap the amount of HCL secreted could be calculated.

In the experiments of the first group simple inert liquids were used such as Ringer or saline. The idea was to cause as little stimulation to the mucous membrane as possible and to eliminate osmotic effects. Saline might have been suitable, but it was thought that since in the kidney the presence of calcium is an absolute necessity for the normal condition of the cell membrane that a more physiological liquid would be Ringer's solution. But as the estimation of HCL was to be performed by simple titration it was not possible to include the usual amount of bi-carbonate because of the buffering effect. For this reason the Ringer's used throughout the experiment was "unbuffered" and had the following composition.

·9g NaCl

·042 KCl Water to 100 cc.

·024 $CaCl_2$

The hydrochloric acid was detected by Gunsberg's test and estimated by boiling out a known volume of the stomach liquid to drive off the CO_2 and then titrating with $\frac{N}{100}$ NaOH till just alkaline to phenolphthalein.

The experiments of the first group fall into two series. In the first an endeavour was made to compare the absorptive and secretory effect of (1) saline and (2) unbuffered Ringer. For this reason each whole experiment consisted of two separate one hour parts in which Ringer and Saline were successively used.

In the second series similar experiments were made on loops of intestine isolated by first clipping off then cutting across and tying in cannulae, and comparisons were made between the absorptive functions of the gastric and intestinal mucous membrane.

Absorption in the Stomach.

Series I.

A. Absorption of Ringer and secretion of HCl.

	Volume of Ringer introduced.	Volume of Ringer removed after 1 hr.	Difference in volume.	Gunsberg's Test.	HCl secreted
	86 cc.	85 cc.	1cc (loss)	+	7 mgm.
1.	75·9	73	2·9 (loss)	slight	1·3 "
2.	81·5	82·5	1 (gain)	"	3 "
3.	58·6	54	4·6 (loss)	+	10 "
4.	91·4	93	1·6 (gain)	++	18 "
5.	64·9	65	---	+	10 "
6.	60	60	---	++	19·7 "
7.	68·8	70	---	+	5 "

B. Absorption of normal saline and secretion of HCl.

	Volume of Saline introduced.	Volume of Saline removed.	Difference	Gunsberg's Test.	HCl secreted.
1.	68·2 cc.	68 cc.	0 cc.	slight	2·6 mgm.
2.	64·8	64	·8 (loss)	slight	2·6
3.	46·6	48	1·4 (gain)	+++	33
4.	86·5	88	1·3 (gain)	++	21
5.	59·3	58·5	·8 (loss)	+	9
6.	56·7	54	2·7 (loss)	-	0
7.	71·0	71	0	+	3

(Nos. 1 to 7 in A and B indicate corresponding 1 hour experiments on the same animal; the order being alternated in successive experiments)

Series II.

Comparison of the degree of absorption of Ringer, in the stomach and the small intestine of the same animal.

	INTESTINE.				STOMACH.			
	Volume introduced.	Volume Removed	Difference.	%Absorption.	Volume introduced.	Volume Removed	Difference.	HCl secreted
12.	7·8cc.	2·3cc.	5·5 (loss)	70				
13.	22·6	trace	22·6 "	100	54·5	56	1·5 (g)	18 mgm.
14.	15·8	7·4	8·4 "	50	51·5	51·5	0	0
15.	36·3	7	29·3 "	80	53	53	2·2 (l)	14 "
16.	24	18	6 "	25	68·2	66	0	4 "

The connections with Ringer were made first with the stomach (one hour), then with the intestine, (one hour).

DEDUCTIONS FROM THESE EXPERIMENTS.

It is quite clear that the method of experiment does not in any way interfere with the intestinal absorption, therefore it is safe to conclude that the stomach is also functioning normally as regards absorption. There is certainly no appreciable absorption of either saline or Ringer in the stomach; and this confirms for decerebrate animals the findings of other workers on anaesthetised. But it is quite obvious that these liquids do cause in the decerebrate animal a certain, though perhaps small, secretion of HCL, amounting only to a very small volume of actual secretion juices.

TESTING OF THE HYPOTHESIS THAT AMMONIUM CHLORIDE SERVES AS THE SOURCE OF CHLORINE OF THE HCL OF THE STOMACH.

It seemed that we might incidentally make use of these experiments to test this hypothesis. It is stated that the mucous membrane of the stomach contains a much higher percentage of ammonia than is found in the tissues generally. It was assumed that if the amount of ammonia or NH_4 ion is related to the HCl produced, the former would show some relation to the acid production.

In the first place the ammonia estimation was carried out on the liquid removed from the stomach by simple aeration. Using this method we failed to find any correspondence between HCl content of the liquid and ammonia content. Even when the HCl secretion was excited by injections intravenously of gastrin prepared by Edkins's method, only in one case did we find other than a trace of ammonia. Hence if there is a production of ammonia parallel with HCl secretion the ammonia does not diffuse into the stomach liquid. The possibility of the ammonia being retained in the mucous covering, which adheres so closely to the mucous membrane, was also considered and the ammonia content of the mucous was determined in several experiments. Here again we obtained no evidence to support the hypothesis often put forward. Neither could we demonstrate any ammonia after hydrolysis with urease which excluded the suggestion that the ammonia might be converted into urea to prevent accumulation of ammonia in the event of a high HCl secretion.

RESULTS.

	HCl secreted.	NH_3 content of liquid.	NH_3 after urease.
	14·9 mg.	———	
(gastrin)	39 "	———	
(weak ")	36 "	———	
(gastrin)	59 "	·36 mg.	
"	41 "	———	
	———	———	———
"	56 "	———	———

PART II.

(a) The absorption of Alcohol from the stomach.

(b) The effect of CO_2 on the absorption of alcohol.

The foregoing experiments have confirmed the view that the stomach is not to be regarded as possessing the power of absorbing water. As already stated alcohol is one of the substances which the stomach can absorb, and it is generally admitted that the absorption of alcohol is increased when taken with aerated water as compared with water not aerated. The characteristic quality of aerated water is the CO_2 content.

Starting with these facts as a basis, two points were the object of investigation:-

(1) To obtain accurate experimental evidence of the absorption of alcohol from the stomach when administered with non-gaseous liquids.

(2) To investigate the effect of CO_2 on (a) the degree of absorption and (b) the rate of absorption.

After washing out the stomach, the diluted alcohol, (which in most experiments was a 5 per cent solution in unbuffered Ringer) was introduced.

Each of the experiments consisted of two parts:-

(a) The absorption of alcohol in Ringer freed of CO_2 by previously boiling out.

(b) The absorption of alcohol in Ringer containing a high concentration of CO_2.

Each part of an experiment was allowed to run for one hour and since the second part might be considered influenced by fatigue the order of (a) and (b) was alternated in successive experiments.

METHOD OF ESTIMATION OF ALCOHOL.

Our method of estimation was the process of distillation under reduced pressure devised by Cannan and Sulzer. Their special form of apparatus was used and the alcohol vapour drawn into a mixture of equal parts of 0·15N Potassium bichromate and concentrated sulphuric acid.

Under these conditions, given a large excess of acid bichromate over alcohol the oxidation is complete to acetic acid, probably to the extent of 90% and over.
The alcohol oxidised was estimated by titration of the excess bichromate. For this purpose we did not use the usual ferrous amm. sulphate but made use of the oxidation of KI with acid bichromate and titration of the iodine by ~~this~~ thiosulpate with soluble starch as indicator.

All the alcohol estimations were done on the same day as the experiments. This is considered a very important point because in the first few experiments when this was not the case alcohol was lost in proportion to the "age" of the sample, making the absorption appear considerable in some cases. When it was realized that the alcohol did disappear in this way the early experiments were disregarded.

This disappearance of the alcohol is probably due to gastric lipase which undoubtedly exists, as has been shown by Hofmeister and recently by others.*

METHOD OF ESTIMATION OF CO_2.

The CO_2 was estimated by withdrawing liquid from the stomach under the surface of a known volume of standard baryta water contained in a small graduated cylinder, noting the volume of stomach liquid, and titrating the excess baryta with oxalic acid, until acid to phenolphthlein. This titration gave CO_2 and fixed acid (HCl). A known volume of liquid was then boiled out, a known amount of baryta water added and excess titrated with oxalic. The differences between these titrations gave the CO_2, while the difference between the titration with the boiled out liquid and the blank titration of the baryta gave the HCl. This last value was checked by titrating the boiled out liquid with $\frac{N}{100}$ NaOH.

THE RATE OF ABSORPTION AND INFLUENCE OF CO_2.

To obtain evidence upon these points liquid was withdrawn immediately after introduction and at 20 minute intervals, each sample was analysed for alcohol and CO_2 content by the methods described. In all, eight of the experiments were carried out on these lines and the results of some are given below.

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*I also have indirect evidence of gastric lipase - when preparing gastric mucin by acetic acid pption and drying with alcohol there was always a considerable production of Acetate esters.

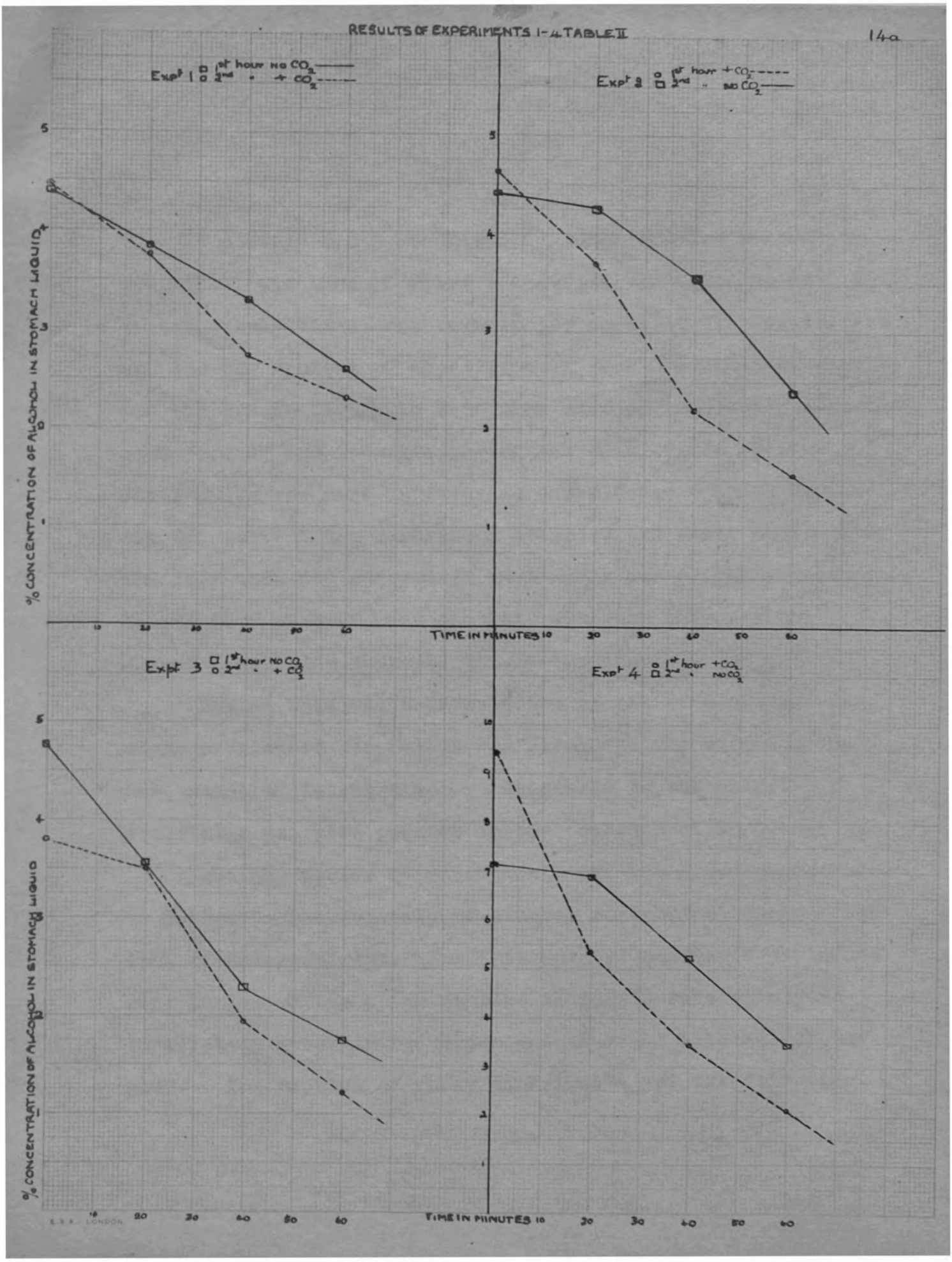
TABLE II. Rate of absorption of alcohol in presence or absence of CO_2.

(a)=No CO_2 present. (b)=With CO_2 present.

Exp.		CO_2 at beginning %	CO_2 at end of 1 hour %	Conc. alcohol at time 0 (introduction). %	Conc. alcohol after 20 min. %	Conc. alcohol after 40 min. %	Conc. alcohol after 60 min. %
1.	(a) 1st hour	None	None	4·38	3·83	3·34	2·61
	(b) 2nd "	66	4·4	4·41	3·77	2·74	2·31
2.	(b) 1st hour	50	None	4·63	3·68	2·20	1·55
	(a) 2nd "	None	None	4·44	4·26	3·53	2·41
3.	(a) 1st hour	None	2·6*	4·77	3·56	2·33	1·75
	(b) 2nd "	52·4	None	3·8	3·53	1·93	1·22
4.	(b) 1st hour	46·4	None	9·36	5·35	3·46	2·10
	(a) 2nd "	None	None	7·11	6·87	5·23	3·46

*This was about the only case where CO_2 initially absent was found to have diffused out from the gastric mucous membrane into the stomach.

RESULTS OF EXPERIMENTS 1-4 TABLE II



DEDUCTIONS.

The experiments need careful consideration before deductions are made. Every precaution was taken to ensure that the only difference between two parts of each experiment was the CO_2 content of the liquid. From the table of results and the graphs it may be said that alcohol is clearly absorbed more rapidly and to a greater degree when CO_2 is present. The results are more striking in experiments 2 and 4 because the CO_2 part of the experiment occupied the first hour. But the fact that the absorption in 1 and 2 was slightly greater in the hour when CO_2 was present, although this was the second hour, also supports this deduction.

Having obtained this evidence of the rate of fall in concentration of alcohol in the liquid in the stomach, the next point of interest was to ascertain if the actual absorption was also greater in the presence of CO_2.

Another series of experiments was therefore performed to determine the quantity of alcohol absorbed throughout the time of an experiment. For this purpose similar experiments were performed, in which samples of liquid were withdrawn immediately after introduction and after an interval of one hour. The results of these experiments are the following.

TABLE III. Absorption of alcohol in presence or absence of CO_2.

Exp.		(a) No CO_2 present. Conc. of CO_2 at beginning. %	(a) No CO_2 present. Conc. of CO_2 at end %	(a) No CO_2 present. Volume of alcohol at beginning. c.c.	(b) With CO_2. Volume of alcohol at end. c.c.	(b) With CO_2. Actual amount of alcohol absorbed. c.c.	(b) With CO_2. HCl secreted in mgm.
1.	(b) 1st hour	42·6	None	2·17	·8	1·67	36·7
	(a) 2nd "	2·5	None	1·84	·6	1·24	48·94
2.	(a) 1st hour	None	0·5	1·79	·39	1·4	21·5
	(b) 2nd "	76·8	2·0	1·53	·43	1·11	31·1
3.	(a) 1st hour	0·45	None	2·24	·5	1·74	3·79
	(b) 2nd "	51·8	None	2·18	·52	1·66	37·85
4.	(b) 1st hour	46·5	1·3	2·43	·71	1·72	7·6
	(a) 2nd "	0·6	None	1·97	1·03	0·94	0·38
5.	(a) 1st hour	0·6	None	2·07	·56	1·51	2·96
	(b) 2nd "	40	None	2·38	·67	1·7	4·74
6.	(b) 1st hour	42·0	None	2·5	·68	1·7	27·0
	(a) 2nd "	3·3	·28	2·53	1·09	1·46	11·5

Concentration of alcohol solution in Exps. 1, 2, 3 roughly 5% (actual amount estimated) and Exps. 4, 5, 6 roughly 6%.
In each experiment the difference between the liquids introduced was solely in CO_2 content.

A consideration of these figures also confirms the results of the previous series of experiments, i.e. that alcohol is absorbed more completely with CO_2 present.

Besides this observation two other points may be noticed if the results of the experiments are carefully studied.

One of these is that the presence of alcohol appears to have a rather striking effect on the gastric mucous membrane with respect to the passage of CO_2.

It was previously proved by N. Edkins that CO_2, in quantities not differing greatly from the normal amount will diffuse until an equilibrium is established, but it appears that when alcohol is present in the stomach this is no longer the case. The figures for the CO_2 conc. in the liquid at the beginning and the end of each hour are given below.

		CO_2 at beginning %	CO_2 at end 1 hr.
Exps.			
1.	(a)	None	None
	(b)	66	4·4
2.	(b)	50	None
	(a)	None	None
3.	(a)	None	2·6
	(b)	52·4	None
4.	(b)	46·4	None
	(a)	None	None
5.	(a)	·45	None
	(b)	51·8	None
6.	(b)	42·6	None
	(a)	2·5	None
7.	(a)	·6	None
	(b)	40	None

From these results it seems that there was a rapid passage of CO_2 inwards across the gastric mucous membrane giving in most cases a fall of from 45% to nothing in an hour. When there was little or no CO_2 in the liquid initially there was, with only one exception no CO_2 at the end. Here there seems to be therefore an exception to the view that the gastric mucous membrane is a passive membrane for the passage of gases. The presence of

alcohol seems to have altered the passive character profoundly and made the mucous membrane "a one way" membrane. That is, CO_2 passes in rapidly and completely, but it is prevented from coming out into the stomach liquid. Since we found no CO_2 present in the liquid removed, regardless of whether CO_2 was originally present or not, we endeavoured to determine whether the presence of alcohol influences the rate of disappearance of CO_2 from the liquid when the CO_2 was present in larger quantities initially.

(N. Edkins's experiments were all made with a low tension of CO_2). For this a few experiments were made similar in all respects to the others, but alcohol was omitted.

		CO_2 at beginning %	CO_2 at end %	HCl secreted mgm.
Exp. 1.	(a) 1st hour	0·23	0·5	0·4
	(b) 2nd "	55·2	8·2	0·34
2.	(a) 1st hour	None	2·3	3·4
	(b) 2nd "	67·2	16·0	0·36
3.	(b) 2 hours	48·2	3·6	3·9

These results show that though there is considerable loss of CO_2 from the liquid the gas never disappears so completely and entirely as in the alcohol experiments, moreover, there is a tendency for the CO_2 content of the stomach liquid to equilibrate with that of the CO_2 tension of the gastric mucous membrane.

The second point is that although a considerable quantity of alcohol is absorbed there is very little absorption of water. If we consider side by side the quantity of alcohol absorbed and the amount of liquid which disappears from the stomach we obtain the following data:-

	Conc. alcohol at beginning %	Conc. alcohol at end.	Vol. of liquid introduced.	Liquid absorbed
(a)	4·38	2·61	76 cc.	1·5 cc.
(b)	4·41	2·31	63 "	incr. 1 cc.
(b)	4·63	1·55	79 "	1 cc.
(a)	4·44	2·41	71 "	incr. 1 cc.
(a)	4·77	1·75	67·5	None
(b)	3·8	1·22	73·7	3·5 cc.
(b)	9·36	2·10	75·9	1 cc.
(a)	7·11	3·46	77·9	None.

The absorption of alcohol was approximately speaking just over half the amount, whereas the liquid absorbed was negligible. It is assumed that the volume is not altered by secretion of gastric juice. Apparently, therefore, the alcohol does not pass through to the mucous membrane accompanied by water, since that would involve a considerable diminution in volume of the liquid in the stomach, whereas practically no alteration in volume occurs. It is possible that the alcohol may accumulate in the mucous membrane and it may be on this account that the membrane exhibits the peculiar character with regard to the passage of CO_2. This might be tested by estimating the alcohol in the blood simultaneously with estimations of the amount absorbed from the stomach; this has not yet been done.

DISCUSSION.

From the experiments we can conclude that alcohol and CO_2 mutually affect one another with regard to their passage across the gastric mucous membrane.

Certainly CO_2 in the alcoholic solution introduced hastens the rate of absorption of alcohol from the stomach and also causes a greater total absorption.

The total amount of alcohol absorbed in either part of an experiment, i.e. (a) in the absence of CO_2 or (b) in presence of CO_2 depends on which part occupies the first hour.

The presence of alcohol also causes the CO_2 to disappear more rapidly and completely and prevents the liquid in the stomach equilibrating with the CO_2 tension of the tissues.

The passage of alcohol in some way profoundly changes the character of the mucous membrane as a diffusion membrane for the transit of CO_2. This gas passes from the cavity into the tissues very rapidly and completly in the presence of alcohol. It even seems to pass from a region of lower to one of higher tension, since it disappears entirely from the liquid in the cavity. Moreover since an equilibrium is not established between the stomach liquid and the tissues, with respect to CO_2, it appears that the gas is barred from passing out to the cavity from the mucous membrane.

There is no reason to believe that the living condition of the mucous membrane is abolished, since it is called upon in ordinary life to meet media of the type employed, nevertheless,

the effect of the alcohol is to cause what may be regarded as a diffusion membrane to be permeable in one direction only.

This effect is well shown in the following experiments. Unbuffered Ringer containing a concentration of CO_2 approximately equal to the gaseous tension of arterial blood was left in the stomach for one hour, the concentration of CO_2 rose to 4%. This liquid was withdrawn and replaced by similar solution of Ringer and CO_2 containing alcohol, the conc. of CO_2 in this solution fell below 1% in the hour. This effect of driving off CO_2 from a region of low tension to one of higher tension is certainly remarkable, it is, however transient, probably dependent on the simultaneous absorption of alcohol.

This fact that alcohol does (a) prevent the passage of CO_2 from the tissues into the stomach and possibly the intestine and (b) causes a very rapid absorption of CO_2 from the stomach liquid, must be borne in mind when alcohol is taken with aerated waters in metabolic experiments based on respiratory exchange.

PART III.

THE EFFECT OF CO_2 ON THE ABSORPTION OF ALCOHOL AND THE INFLUENCE OF ALCOHOL ON THE DIFFUSION OF CO_2 IN THE SMALL INTESTINE.

The foregoing investigation had shown that CO_2 increased the absorption of alcohol by the gastric mucous membrane in the cat and that the presence of alcohol in the stomach had the curious effect of apparently making the mucous membrane of the stomach permeable in one direction only. The present investigation was undertaken to determine whether these effects were also exhibited by the mucous membrane of the intestine. (Also a comparison can be made between the effect on stomach and intestine.)

METHOD.

The method employed was similar to that used in dealing with the stomach. The animal was anaesthetised with ether and decerebrated by Langley's starch injection method, artificial respiration being applied. Eight inches from the pylorus a piece of S.I. 55 cm. long was measured off and clipped with Spencer Wells forceps. At each end a cannula connected with a tap was ligatured into the loop; and the loop was washed out with warm unbuffered Ringer's solution. The upper cannula was connected with a side tube between it and the tap, and through this tube the liquid to be investigated was introduced and kept at a constant pressure of 5 cm. of water.

The basic experiments as in the case of the stomach were done with unbuffered Ringer only. The table given below shows results which enable us to compare the absorption from the stomach and intestine in the same animal. The intestinal absorption though very variable is always considerable.

Series Ic.

COMPARISON OF ABSORPTION IN THE STOMACH AND SMALL INTESTINE.

	Intestine				Stomach			
	cc.Ringer introduced.	cc.Ringer removed.	Difference.	% absorption.	cc.Ringer introduced.	cc.Ringer removed.		HCl mgm.
12.	7·8	2·3	5·5 loss	70			(absorption)	
13.	22·6	trace	all	100	54·5	56	1·5 gain	·018
14.	15·8	7·4	8·4	50	51·5	51·5	--- ---	---
15.	24	18	6	25	68·2	66	2·2 loss	·014
	36·3	7 cc.	29·3	80	53	53	---	·004

The alcohol experiments were done on the same lines as in the case of the stomach, i.e. each experiment consisted of two parts, each part was only of one hour's duration. In (a) about 8% alcohol in unbuffered Ringer was used and in (c) the same alcoholic solution to which about 44% of CO_2 had been added. In some experiments solution a was used first and then solution c, and in others the solutions were used in the reverse order.

TABLE AND DISCUSSION.

Exp.		ccs. alcohol absorbed.	Volume liquid absorbed.	CO_2 at beginning.	CO_2 at end of exp.
1.	(a)	1·565	16·6	0	?
	(c)	2·38	23·2		?
2.	(c)	1·53	19·8	abt. 44	?
	(a)	1·08	2·4	0	?
3.	(a)	1·712	11·5	0	9·9
	(c)	1·817	8·85	44	8·4
4.	(c)	1·287	9·9	40	1·7
	(a)	1·121	4·3	0	1·6
5.	(a)	1·0	5·2	0	2·0
	(c)	1·0	1·5	43	2·0
6.	(c)	2·03	25	43	3·9
	(a)	1·399	3	0	3·5
7.	(a)	·755	-2·4	0	1·4
	(c)	·686	-9·5	43	1·7
9.	(c)	1·275	4·6	44	1·4
	(a)	·696	-3·6	0	1·6
10.	(a)	1·04	2·0	0	1·2
	(c)	1·11	-1·0	48	1·2
11.	(c)	1·06	8·6	0	3·2
	(a)	1·06	0·0	48	2·0
12.	(a)	·714	6·3	0	1·6
	(c)	·513	0·0	48	2·0
13.	(x)	---	11·4	0	1·4
	(y)	---	9·3	24	1·9
14.	(y)	---	7·2	56	3·1
	(x)	---	7·9	0	3·2

From the above table which was a sample of the results obtained it was clear that as far as CO_2 was concerned either the mm. of the small intestine was acting merely as a passive membrane or the CO_2 was the result of secretion. With regard

to the absorption of alcohol in the presence of CO_2 there seemed to be a tendency for more alcohol to be absorbed in the presence of CO_2 though the effect is not nearly so marked as in the stomach.

In the second part of the experiment peristalsis always occurred and usually less alcohol was absorbed, but the difference was less marked when there was CO_2 in the liquid in the last part of the experiment than when it was introduced first.

Restating some of the results already presented in (c) and (d) we can take a comparison between the degree of absorption from the intestine with and without alcohol in the following way:-

COMPARISON.

A. % absorption of Ringer with alcohol.

	Cont: CO_2	No CO_2
(a)	0 (2)	37 (1)*
(b)	25 (1)	0 (2)
(c)	0 (2)	8·5 (1)
(d)	16 (1)	0 (2)
(e)	5 (2)	20 (1)
(f)	31 (1)	20 (2)

B. % Absorption of Ringer without alcohol.

(a)	70%	
(b)	100%	
(c)	50%	
(d)	25%	
(e)	80%	
(f)	22%	(1)
(g)	22%	(2)
(h)	30%	(1)
(k)	38%	(2)

* numbers signify dual parts of experiments.
(1) = first $\frac{1}{2}$ hour.
(2) = second $\frac{1}{2}$ hour.

We can also conclude that alcohol does not hasten the absorption of liquid but has rather the reverse effect, since the figures for the absorption of liquid with alcohol were very nearly always considerably lower than in the case of unbuffered Ringer alone. What is more, alcoholic absorption seems to slow down the absorption of liquid very rapidly, since in the 2nd part of an alcoholic experiment there was very often no absorption at all, whereas in the 2nd half of a simple Ringer experiment there was very little difference from the first.

From all these considerations it would appear that alcoholic liquids may not be nearly as efficient as water in quenching the thirst.