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Gastric Digestion.

An Experimental and Clinical Study of Some Points with regard to the peptic digestion of Proteids.

By
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Part I

Introduction.

This essay contains the result of five years work on the subject of Gastric digestion. The work was not continuous, but was done during hours snatched from other duties. This will explain, I hope, the somewhat disordered arrangement of my dissertation. In fact I consider it more as a series of studies on the subject of the peptic digestion of Proteids, in which the central fact is the combination of hydrochloric acid to albumenoids, than as a comprehensive Treatise.

I have, however, for the sake of clearness and order, described in a separate part the more important of the methods used, and in another part the general history of the subject. Any deviation from the methods, as given separately, is noted in the sequel. In this way, I believe, I have spared much vain repetition.

The following parts of the Essay

table up, seriatim, the subjects of, first, the course of the acidity in artificial and natural digestion, its forms and products, secondly, an investigation into the properties of combined Hydrochloric acid, the "acide chlorhydrique combiné organique" of the French, the "Gebundene Salzsäure," of the German authors. Thirdly; the microorganisms of the stomach contents are examined, and lastly the general question of digestion and indigestion is considered.

I wish to record my deep sense of obligation to Dr. Claud Muirhead for many kindnesses and for allowing me to examine cases in his Wards in the Royal Infirmary, Edinburgh, and to Drs. Noël Paton and Cathcart Wood for many useful hints, given me when working in the Laboratory of the Royal College of Physicians Edinburgh, where most of my experiments were performed.

The figures in red throughout the work refer to the number of the book or paper referred to, as catalogued on pp. 8—26.

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Part II

Historical

Chapter I.

General History of Gastric Digestion.

Before Réaumur's time little was known about the digestive process. It was imagined that it was simply a mechanical process going on in the stomach, or that it was solely due to the action of putrefaction.

Réaumur's[125] researches, however, did much to alter these ideas. He gave birds hollow and perforated metal balls filled with food to swallow and, recovering them again by means of strings attached to them or when passed per anum, he proved by examination of the contents that the act of digestion was not mechanical for, although the food had almost disappeared, yet the metal capsule was as before.

Shortly after, Spallanzani[23] showed that the Gastric juice of various animals digested meat outside the body, and he also discovered that it prevented to a large extent the occurrence of putrefaction. He opened the body of a snake which had, several days before, swallowed a lizard. He found the lizard half digested, but with no trace of putrefaction.

In 1825. Tiedeman[25], Gmelin[26], Leuret and Lassaigne showed that in artificial digestion experiments the Gastric juice was the sole factor.

The year before, Prout[178] had shown that the acidity and potency of the Gastric juice was due to the presence of Hydrochloric acid, and his discovery has been confirmed since then by innum-

erable obscures, although Lassaigne (1825) Lehmann (1850) and Blondlot[3] (1857) attributed its action to acetic acid, lactic acid and acid phosphate of Calcium severally.

Bidder[2] and C. Schmidt (1852 - 53) however conclusively proved that the acid in the Gastric juice was the Hydrochloric acid by showing that there were not sufficient bases in it to satisfy all the Chlorine present. These results were confirmed by Lalonde Szàbo[156] and others.

Rabuteau[123] (1875) by combining the HCl of the Gastric juice with Quinine procured an insoluble salt which he could weigh and examine, but his method requires complicated apparatus.

Beaumont's[1] classical research on Alex is St. Martin appeared in 1825 and threw a flood of light on many disputed points; while Eberle[49] (1834), who first used an artificial gastric juice, Schwann, who first discovered Pepsine, Wasmann (1839) who isolated it, Mialhe (1846) who worked at the products of digestion, calling them albuminoses, and Lehmann, who named the ultimate products Peptones, all advanced the physiology of peptic digestion

Meissner[110], Brücke, Meissner, Hammarsten, Maly etc (1859 — 1876) worked at the proceeds of albuminoid digestion. And about this time two schools sprang up, one of which, Thiry, Hoppe[119] etc explained the splitting up of albumen

into albumoses and peptones by a theory of depolimerisation, the other, including Maly, Hoppe-Seyler & Danilewski[46b], relied on a set of hydrations.

Danilewskie[46] (quoted by Hayem & Winter[13]) found that during pancreatic digestion albumen gained in weight. Maly arrived at the same conclusion from the heat phenomena accompanying the dissolution of albumen into peptone.

Pohl on the other hand regarded the changes of albumen as being chiefly mechanical, molecules of water interposing between molecules of albumen.

The researches however of Kühne[91, 92] and Chittenden confirm in part the original work of Meissner[110], and they find that albuminoids separate in digestion into a part easily digestible and going on to the formation of Leucin and Tyrosine, and also into a part not easily attacked by the digestive ferments.

Chapter II.

Review and criticism of the later Work on Gastric Digestion.

1. Acids.

Various reagents have been suggested within the last few years both for the qualitative and quantitative testing for the acids of the Stomach juice or contents. And here I think I may protest against the common use of "Gastric juice" in cases of Dyspepsia; it is a term that is inexcusable, for when during life and especially in practice, unless it be in a case of hypersecretion, and then only before breakfast, do we meet with "Gastric juice"? It is always, or nearly always "Stomach Contents" which we examine, or even more often the products of a "Stomach Wash" And yet in nearly every paper describing the examination of the fluid siphoned off from the Stomach it is called "Gastric juice", a gastric juice with bits of muscle floating in it, filled with starch or sugar!

Prout[178] by distillation of the stomach contents carried over in the distillate some HCl, which he measured by means of Silver Chloride.

Bidder and Schmidt's method, and the method of Rabuteau have already been mentioned above

Ch. Richet[131] repeated Bidder and Schmidt's experiments and applying Berthelot's law of the "Coefficient of partage", which depends on the power

ether has of taking up a constant quantity of an acid mixed with it, he found that the acid present was taken up extremely feebly, as are mineral acids, by Ether. On working at the subject further however, he found that the Hydrochloric acid in the Stomach did not act on ether as the pure and per acid does and suspected that it might form some compound with organic matters and, again, on dialysing a solution of pure HCl in water and of HCl in a stomach fluid he found that they did act quite similarly. He ultimately came to the conclusion that the HCl of the Gastric contents is a combined acid "analogous to or identical with Hydrochlorate of Leucin." He has been generally credited with the assertion, — in this country at least (see Michell Lancet 45) — that it is combined with Leucin, while he only says that it may be identical with or analogous to that combination, and elsewhere he speaks of an "Acide Chlorhydrique Combiné Organique" in a more general sense.

Ewald[8] combats Richet's views.

(ahn and Von Mehring[39-40] published a method of estimating the acids by combined distillation and titration, they distilled the fluid to one quarter the original amount, added water to the original quantity and again distilled to $\frac{1}{4}$. The fluid remaining over was well shaken 6 to 8 times with ether and redistilled until all the ether had been

removed. The first distillate contained the volatile organic acids, the second the Lactic acid and the third or remainder the HCl, these were severally titrated. Macnaught simplified the proceeding by estimating the total acidity first, then the acidity after the fluid had been evaporated down to a syrup, the subsequent proceedings were similar.

These methods are however uncertain no note being taken of the organic acids combined with Proteids or of the acid phosphates.

Sjöquist[15-1] by means of pure carbonate of Baryta estimated the acidity. He proceeded as follows, 10 ccm of the contents of the stomach were heated on a platinum capsule with an excess of pure Carbonate of Barium, then for a few minutes incinerated. The ash was washed with hot water and the extract filtered until 50 ccm had been obtained through the paper, the Chloride of Barium thus obtained can be estimated either by means of Bichromate of Potash and Tetramethyl paraphenyl diamin papers, which show by changing to blue a trace of Bichromate of Potash; or better by converting the Chloride into the Sulphate of Barium and weighing it, as V. Jaksch[15] and Leo[16] have pointed out.

The method is too complicated for clinical work and takes no heed of the difference between the combined and uncombined acids.

Bourget[37] in 1889 described a modification of Sjoquist's method in which he made some distinction between the acidity due to organic-acids and that due to HCl, after incinerating the fluid with Barium Carbonate and digesting with warm water he precipitated the Barium Chloride with Caustic Soda, caught on a filter paper and washed until the wash water had no further alkaline reaction.

10 ccs of a 1% HCl solution is added and the loss of acidity titrated, this equals of course the original acidity due to HCl, a total acidity determination beforehand revealing the HCl + the organic acids.

Leo[99] also in 1889 brought out a method which depends on the addition of $CaCO_3$ to the fluid to be tested, acid salts having little or no effect on it, while it neutralises free acids.

Mintz by titrating with Soda until he could get no reaction with Phloroglucin-Vanillin in the fluid, while Boas[4] by using in a similar manner Congo red sought to achieve a quantitative estimation of HCl, but counted the organic-acids as well, unless as Boas recommended the fluid was shaken with an excess of Ether beforehand.

Hoffmann with great ingenuity estimated the HCl present in a stomach wash by measuring the quantity of Cane sugar inverted by it, the organic acids having so little inverting power

that he could ignore them. But as Boas points out, both Hoppe-Seyler and Uffelmann have found that the Gastric mucus has considerable inverting power.

Leube[18] recommends A. Braun's method in which the HCl is converted into NaCl by adding Caustic Soda to alkalinity, the amount of Soda used to form the NaCl estimated, and the corresponding amount of HCl subtracted from the total acidity.

We next come to the excellent work, published last year, Du Chimisme Stomacale[13], a continuation of the work of Richet, Mathieu and Bourget; it marks a distinct advance in our knowledge of testing the stomach contents. The whole work is based on the fact that HCl, being volatile, is driven off, when in the free state, by a heat of 100° – 110° Centigrade. If 10 ccs of an aqueous solution of HCl, for instance, be submitted to that temperature for some hours, on testing the dry residue, if there be any, no free HCl is found, in fact no acid whatsoever. On the other hand if, instead of water, the HCl be added to a solution of Proteid material on Waporation, and on continuation of the heat for, at least, one hour after the solution be thoroughly dry, although there may be still some acidity, yet by applying Günzburg's Reagent no free HCl can be detected. On testing the solution for Chlorine however a

considerable increase is over the amount found in the original solution of Proteid, can be found.

To estimate these changes exactly use is made of the ease with which Chlorine can be gauged by means of a standard solution of Nitrate of Silver. To obviate the fallacies present in this method when Proteids are present in the solution, they subject the fluid won from the stomach to four different processes. They first test the total Acidity in the usual manner with a decinormal solution of NaHO and Phenol-Phthalein as indicator, calling it A. Next the authors, Messrs Hayem and Winter, add an excess of pure Carbonate of Soda to 5 ccs of the fluid, dry at the heat required to fuse the Soda Salt and titrate the Chlorine, this they call T, or the total Chlorine, the Proteids having been charred by the heat used. Drying 5 ccs in a capsule for some hours at 100° – 110° Cent., they dissolve the residue in distilled water and treat as before, this gives the Chlorine combined to albumenoids, as well as the fixed Chlorine or the Chlorides. The fixed Chlorine is estimated by incinerating 5 ccs in a capsule, & titrating. This is called F, the letter C standing for the Chlorine combined to Proteids, or the total combined Chlorine minus the fixed.

A simple subtraction will give the free Chlorine

that is, the Chlorine driven off at 100° Cent.

$T - F + C = H$. That is the Total Chlorine minus the Fixed and organically combined Chlorine equals the free Chlorine or H. Again it is evident that, if HCl is the only acid in the Stomach $\frac{A - H}{C} = 1$. or the Total acidity minus the free HCl equals the Chlorine organically combined. This proportion is called α, and serves as an index of the amount of the Organic acids present. For if A. be made up both of HCl in some form, and of Organic acids $A - H > C$, or $\alpha = 1+$, but if all the Hydrochloric acid be combined the equation still holds good. α, however, $= 1-$ when some of the Chlorine is not combined to Proteids but to Ammonium salts or the "Chlorhydrates d'ammoniaques organiques, which are decomposed by the heat. When α is more than 1 the digestive power is diminished. These are convenient symbols and the authors point out that the amount of C. shows the actual work done by the Gastric Juice, that H shows its power still available while α serves to denote the occurrence of any fermentation. A very thorough table is given of all the variations of these factors (p. 154) but it is too long to quote. The types of Dyspepsia, — Hyp acidity would be the better

name — are given as Hyper — Hypo — and Apepsia. From many analyses the normal limits of the acidity and Chlorine are described as follows; — Total acidity .18 to .24 % (HCl), Free HCl, .025 to .05 %, the Chlorine organically combined as .135 to .18 %, the Total Chlorine, .3 to .34 %, while α varies from .8 to .92. — The principal point in this table is the small percentage of free acid given, and I believe they are the first observers to note this. I hope to corroborate them in this point later on. (Vide p. 195.)

There are several other matters of importance in the book, for instance by examining the stomach contents from a dog during the digestion of distilled water they found a very considerable quantity of fixed Chlorine, which they regarded as secreted with the Gastric juice but which seems more likely, to me at least, to have been swallowed with the Saliva; in these experiments too, they found that there was only a trace of free HCl in the contents, .002 to .022 %. while Combined Chlorine appeared to .13 %, combined to what is not stated, probably to mucus.

Another result of their investigations is the law that the Total Chlorides reach their maximum the sooner, the lighter the repast.

One or two other smaller matters will be referred

to where necessary.

To sum up then, Hayem and Winter have undoubtedly elaborated a method which, though too cumbrous for any one but specialists, seems to give very accurate results. If I wished to find fault with it at all I would point out that during the many heatings some, often a pretty considerable portion of the Chlorine is burnt away, as may be seen easily if the flame of the Bunsen be placed over the capsule in which the incineration is proceeding, secondly that they have only in a few places stated the hour at which their determination of the acidity and Chlorine was made, and that they have not, with any great care or persistence, analysed the contents at either regular hours or in series; thirdly and lastly the lack of any reference to the digestive power of the Stomach contents in too many instances.

The acidity due to acid phosphates is almost ignored in Hayem and Winter's work, and, indeed, they remark, what I believe is perfectly correct, that Ewald and most of the German School lay too much stress on the acidity due to these salts, for, as a rule, the quantity present is infinitesimal.

The authors attribute very little digestive power to the Stomach, saying that it is chiefly an antifermentative organ and that the changes

produced in the food are preparatory only to other changes in the intestine. To my mind their conclusions are not warranted by the facts deduced by themselves partly, and partly from Cahn's work and the facts I shall hereafter detail. That it is a powerful antifermentative organ cannot be doubted in reference to Macfadyen's work on the microorganisms in the Stomach and their resistance to acids. But, if Rosbach's observations are to be relied on, that is, if in men, as in the dogs he examined, the pylorus only relaxes at the end of 4 to 6 hours and squirts out the stomach contents in 4 or 5 jets, a large quantity of Proteid must be absorbed by the coats of that organ; for if the course of the combined Acidity or Chlorine, as depicted by Hayem and Winter, be accepted as an index of the digestion going on in the Stomach — it rises rapidly for the first 2 to 3 hours and then almost as rapidly decreases, — and therefore of the Proteid present, the decrease after the third hour must be due to absorption of these Proteids with the acidity or without it. Then of a sudden, the Pylorus opens, the combined Chlorine sinks to zero, and a trace of free HCl is left.

Cahn[41] however, in some careful experiments conducted with a view of discovering the amount of HCl at the different periods of gastric digestion,

— his experiments were performed previous to the appearance of Hayem & Winters work, — came to the conclusion that the stomach continually is letting some of its contents out through the Pylorus.

He used a dog for most of his work, and I consider it worth while here to reproduce his tables.

1. To show the difference between one dog and another under the same circumstances.

minutes	A HCl %	B HCl %
30	·074	·074
60	·082	·164
90	·099	·186
120	·14	·288
150	·246	·222
180	—	—
Average	·128	·186

The acidity of No 2, or B. rises higher but falls sooner than that of A while the mean is higher.

2. For this experiment and the following one he used "Carne-pura-pulver", dried beef powder to feed his dog, giving as a preliminary 5·0 grs of this suspended in 300 ccs water. On testing the acidity after 1 hour he found the acidity on 6 occasions ·12 ·12 ·11 ·1 ·13 & ·11 % HCl

He then proceeded further, giving the dog the same meal, i.e. 50 grms meat powder = 43 grms when absolutely dry, and containing 33 gr Albumen, suspended in 300 ccs water.

Minutes	Dissolved.						Residue
	HCl %	HCl absolute	Water	Solids %	Solids absolute	% Syntonin	
30	·098	·348	343	2·82	9·88	–	–
30	·082	·3	372	2·94	10·93	·33	29·8
60	·117	·23	193	2·54	4·89	·11	–
60	·103	·26	252	2·22	5·59	–	23·5
60	·124	·24	196	2·32	4·54	–	18·4
60	·117	·28	236	2·6	6·14	–	20·1
60	·116	·19	109	2·28	3·86	–	19·3
90	·134	·35	266	3·14	8·39	·10	17·1
120	·154	·43	286	3·22	9·22	·26	12·6
150	·207	·37	181	3·53	6·41	.19	8·1
180	·387	·43	106	6·	6·34	:18	2·5
210	–	–	–	–	1·98	–	·8

The total contents of the stomach were extracted each time. The dissolved solids are most at the half hour and decrease as time goes on. Unfortunately he did not estimate the total Proteids in this or in the next experiment,

3. Similar to last, but with 30 grs of the powdered meat = 25·5 gr when dried = 18 gr of albumin. In this case the solids dissolved were again treated

at the 30 minutes.

	Dissolved.							Residue
minutes	HCl %	HCl absolute	Water	Solids %	Solids absolute	% Syntonin	% Peptone	
30	·119	·35	296	2·81	8·31	·14	2·18	13·7
60	·134	·27	199	2·85	5·65	·11	2·	10·15
90	·17	·22	129	3·56	4·59	·14	2·64	3·8
120	·191	·26	143	3·85	5·53	·15	2·86	4·1
30	·121	·32	264	2·94	7·44	·16	1246	12.
60	·14	·34	247	2·82	7·	·11	2·15	8·4
90	–	–	–	–	3·5	–	–	5·14

The peptones were estimated by Gilddahl process and probably contained a large amount of albumose. The total contents of the stomach being evacuated at each testing, renders the sequence of events less certain, as even slight circumstances change the course of events.

From these experiments I am believed that most of the Stomach contents were expelled into the Duodenum with the Proteid matter peptonised, I think however, that the fact he lays most stress on, the uniformity in the percentage of Peptone, points rather to absorption than expulsion, and I believe if he had more carefully differentiated between the albumoses and Peptones he would have found that his figures were incorrect. I return to this later.

The other works on the same subject are referred to in the course of this essay.

While I have thought it better to go over the qualitative tests proposed for HCl and the Organic acids when describing Methods in Part III.

Chapter III.

On the work done with reference to the micro-organisms found in the stomach.

In discussing the use of the Gastric juice and the meaning of its acidity Bunge[6] after giving the results obtained by Sieber[150] and Miquel[115] concerning the amount of Hydrochloric acid requisite to prevent putrefaction, and by Dionys Szabo[15-6], in Hoppe Seylers laboratory, in estimating the quantity of free (?) Hydrochloric acid in the contents of the Stomach, when removed without the addition of water, writes as follows. "We come then to the astonishing result that the amount of HCl in the stomach juice is exactly that which suffices to check the growth of micro organisms! This similarity cannot be a coincidence."

loc. cit.

In 1784 Spallanzani had already discovered that the stomach juice was an antiseptic, while Lassobel

and Boedeker corroborated by P. Sanceri and de Luca examined the saliva of the Delfinus Galea, found 2·7 % to 4·1 % of free H_2SO_4 in it and also proved that it was antifermentative in its action.

Now, although the acidity of the Stomach juice is sufficient to prevent fermentation occurring in the normal state, it is unlikely not strong enough to kill many of the microorganisms, only inhibiting their action for a time, while on the other hand, though some organisms are easily killed by the acidity, others are exceedingly resistent, notably those which cause the Lactic and Butyric acid fermentations. those belonging to the same class as the Bacterium or Bacillus — as it is now called, — Coli communis, and again the spores of Anthrax, as Hauk[59] pointed out, or of Tubercle. (Falk[57]).

Yeasts and Sarcinæ growing naturally in acid media, live undisturbed, only getting a decided footing however when there is stasis of the Stomach contents.

In 1885, W. de Bary[32] investigated the organisms which normally live in the stomach, and found among these the Sarcina Ventriculi, the Oidium Lactis, and different Bacteria and Mucors, but he does not go into the chemical or pathological significance of their growth, further than to show that their presence betokens a fermentation similar, in the case of the yeasts, to the ordinary

yeast fermentation, and in the case of the others to separate and different fermentative processes.

Since Goodsir, 1842, discovered and described the Sarcina Ventriculi much has been written about it. Indeed Reinhs, quoted by Ewald, remarks that more would has been done on it than was ever warranted, a remark which Ewald endorses. Fallenheim[58] has collected the literature and carefully examined the subject without discovering anything of much value. Richter[130] published a case of blocking of the Pylorus by masses of Sarcinae which he cured by washing out the stomach with a solution of Hyposulphite of Soda.

He performed the following experiments:

1. 30cc of the Stomach wash + ·02 gr. Salicylic Acid. In 24 hours brownish Sarcinae in groups, few white or in small packs. Torulae growing. Bacteria few.

2. 30cc + 15cc. $HgCl_2$ 1/1000.

Sarcinae wrinkled, brownish yellow. Few Torulae.

3. 30cc + 15cc $HgCl_2$ 1/10000

Yellow sarcinae, granular, edges not sharp, many bacteria and micrococci

4. 30cc + 15cc solution of Hyposulphite of Soda, 1 in 4.

Sarcinae wrinkled, brownish yellow, few Torulae.

5. 30cc left for control

Many brown and white granular Sarcinae. Bacilli and cocci in numbers. Torulae sporulating.

Three days after no Sarcinæ were seen in No 4, only Bacteria and Torulæ, while in No. 1. there were no Bacteria but some very disorganised Sarcinæ. The Sarcinæ were either white with sharp edges, (or, as Richter regards them, healthy,) or on the other hand yellow granular with obscured edges, in fact in an unhealthy condition.

I need only point out that Richter's methods were very imperfect and rough and cannot regard his contention that the stoppage of the pylorus by huge balls of Sarcinæ as proved or as even probable.

In 1884 Abelous 29 found 16 different microorganisms in his own stomach which he washed out with very precaution. Among these were

1. Sarcina Ventriculi
2. Bacillus Pyocyaneus
3. Bacterium lactis aerogenes (d'Escherich)
4. Bacillus Subtilis
5. Bacillus Mycoides
6. Bacillus Amylobacter
7. Vibrio Rugula
8. An unnamed Coccus

and 8 other unidentified organisms, bacilli principally. All these organisms withstood a ·17% solution of HCl in a flask when grown in it and kept for longer than the ordinary duration of digestion. They also produced

certain products when grown on albumen, milk, fibrin, gluten or on glucose but he fails to specify which organisms produce the different bodies from the media. He asserts however that they are nearly all anaerobiotic and that probably they act in the intestine on foods.

Two other French observers, Capitan and Moran[47] cultivated organisms from the stomach in thirty cases, but failed to grow more than three varieties. Sometimes the stomach contents was a pure growth of one species. The first they obtained was the Pink Torula, the second a rapidly growing organism which did not liquefy gelatine but grew as a white grey sheet, moist and dry in places and having toothed edges, it was probably a mucor. The last variety was a Bacillus, larger than the Bacillus Tuberculosis, which liquefied gelatine and gave a citron yellow colour on potatoes; it was not identified by the observers but seems to be like the Bacillus (or Bacterium) Coli Communis, except that it liquefied gelatine. Falk[57] in a long article in Virchow's Archiv relates his experiences with regard to the resistance of microorganisms to the acid of the stomach. He found that Penicillium Glaucum was unaffected by stomach juice, that Aspergillus fumigatus was inhibited by putrid growths of Bacteria, although artificial gastric digestion had no effect

on its vitality. Following Grube[66] who injected organisms into the blood stream and produced diseases, Falk[57] injected bacilli and other organisms both before and after artificial digestion with very little result in any way.

Cohn, Koch and Buchner gave mice cultivations of the Bacillus Anthracis to eat without producing infection. Renault[127] in the same way found that while no infection occurred in Carnivora or omnivora herbivora soon caught the disease and died. Gerlach corroborated this. Cohn using gastric fistulae found the anthrax given by the mouth became inoperative after digestion in a carnivorous or omnivorous stomach.

Pasteur worked at the same subject when investigating Anthrax and found that if he mixed sharp substances such as small bits of glass with the food in which anthrax germs had been mixed and gave this mixture to carnivora, infection ensued. Huber[78] arrived at the same result.

Falk found saliva, pancreatic juice or bile to have no effect but that the Gastric juice killed the Bacillus Anthracis, while of pure HCl .11% sufficed to kill. Alkalis with Papain also had no effect but putrefactive bacteria in quantity inhibit the growth or even kill.

Tubercle Bacilli again were killed in the stomach of the dog but lived through the digestive process.

in the rabbit and usually lived through artificial digestion experiments.

Falk laid great stress on the value of the Ammonia produced in putrefaction as an anti-fermentative, in contradistinction to McFadyean who believes more in the Acetic and Butyric acids formed during the process.

Spores of Microorganisms have been found to be much more resistant to the action of the Gastric juice than the organisms themselves. Pasteur injected 33% with the spores of anthrax, giving them by mouth, in animals who resist the action of the bacilli themselves if given in that way, while he raised the number even higher than that if he added sharp substances to the diet as well.

Kaufmann [119] investigating in a very superficial manner the contents of dilated stomachs found Sarcinae, moulds, yeasts and bacteria in large quantities, these always diminished after careful washing out of the stomach for a day or two. More interesting is his account of the products found in a dilated stomach such as Lactic and Butyric acids, alcohol, Acetic acid, glycerin, "Bernstein säure" (Succinic acid), the higher homologues of butyric acid, and an inflammable gas, probably marsh gas.

The most careful work that has been done

on the micro organisms in the stomach and their resistance to acids is that of Macfadyean's.[103] in 1887.

Macfadyean first goes over the history of the subject mentioning besides Falk's researches those of Hankl[59], Miller[113], Maly[105] and Smith[105], and Lindberger.[107] I have already noted the results of Falk's work. Hanks essay covers the same ground and he concludes that 0·29861% HCl + ·1% pepsin, even after six hours, is not able to destroy tubercle germs; while anthrax material shows itself still virulent after an hour under action of 0·12% HCl. He however ignores the distinction between spore free and spore-containing bacilli. Miller as the result of his experiments on dogs concludes that germs can live six to eight hours in the stomach of a healthy dog. He first cultivated germs from the buccal cavity then gave them in quantity with a mixed diet to the animals, killing them at different hours after. Maly and Smith, Ridder and Schmidt, and Rafalmi attributed antiseptic powers to the Bile a point which does not concern us here. Lindberger found that Hydrochloric acid had a stronger antifermentative action than Lactic acid, but that Bile unless it was rendered acid had only slightly that action. Rimstock[34] noted that although he could see many forms of Bacteria

in the contents of the stomach and intestines, yet he could only cultivate a few of these varieties.

Passing on now to the experiments of Macfadyen, which are divided in those conducted without and those conducted within the body, we find that he used the following Bacteria for his purposes

1. Staphylococcus Pyogenes Aureus
2. Micrococcus Prodigiosus
3. Saprophytic Bacillus
4. Bacillus Pyocyaneus
5. Micrococcus Tetragenus
6. Septicaemia of Rabbits (Bacilli)
7. Anthrax Bacilli
8. Typhoid Bacilli, spore free.
9. Comma Bacillus
10. Müller and Prior's Spirillus.

These germs were grown on gelatine plate, the gelatine being acidified with Hydrochloric acid, or combined with Pepsine in different preparations. Pepsine alone had no effect on the organisms. Hydrochloric acid hindered the growth in all the organisms either alone or when combined with pepsine when the action was the same.

Staphylococcus was killed by .3% HCl,

Typhoid Bacillus by .3% HCl

Micrococcus Prodigiosus and Müllers Spirillus killed by .05%.

The Micrococcus tetragenus and the Saprophytic Bacillus killed by .2%, while the Anthrax required .1% and Koch's Cholera Bacillus only .05%.

Summing up the author remarks, among other conclusions, "that the resistance of the germs is against such a strength of acid that, à priori we might say they could pass through a stomach containing a normal proportion of Hydrochloric acid without being killed, and with much greater facility in cases of lessened acidity."

On testing the antiseptic power of the bile, Macfadyen found that it was very small or altogether absent, this power which is so often ascribed to it being in fact due to the anti-fermentative action of the organic acids found in the intestinal contents. .1% Acetic and Butyric acids were found to be able to check the growth of the Typhoid Bacillus, Comma Bacillus and the Blue Pus Bacillus, among others, without the presence of bile. while between .1 and .2% of Lactic had the same effect. Admixture of Bile and the bile acids or salts had no further influence on the action of these acids.

Thol [26] also investigated these organic acids and came to the same result, finding however that Formic acid was the most powerful of the series, corroborating Hoffmann's note on it.

Of the experiments done in the living body, Macfadyen, giving Staphylococcus Pyogenes Aureus to dogs found large numbers in the intestines five hours after, both with a meat diet and one consisting solely of milk. Of the less resistant germs on subjecting them to a similar trial, both the Anthrax Bacillus and Koch's Comma Bacillus were killed, while a greatly diminished number of the Bacilli of Rabbit Septicaemia and of the Micrococcus Tetragenus survived.

As my researches will be more particularly devoted to the study of those Bacteria living in the stomach and their effect on Dyspepsia and the composition of the Gastric contents, these experiments on other organisms can only be comparative, for most of the organisms cultivated from the Gastric juice must necessarily have some resistance to acids. Still these results are very instructive and serve to show that in an enfeebled patient with the Gastric juice weak in acid, there is always great danger of organisms passing through the stomach into the intestines and if there be any inflamed part there, passing through the wall into the blood and possibly setting up disease. They also point out the ease with which resistant germs may pass down into the intestines and setting up fermentations cause diarrhoea or intestinal catarrh.

In another and almost more interesting papers published later the same author in conjunction with Sieber and Kenaki[104] investigated the process of digestion in the small intestine with special reference first to the Chemistry, secondly to the Bacteriology. The second part interests us most here, but it will not be amiss if I give a short note of the results of the chemical investigation.

The observations were all made on a woman with an artificial anus at the junction of ileum and Colecum. With a fixed diet in which proteids predominated the contents discharged were thin, if carbohydrates on the other hand were in excess the discharge was porridge like. It was constant in both cases but only in very small quantities during the night. After noting the period at which certain articles of diet such as peas, or medicines as salol appear, the authors give some interesting chemical particulars.

The discharge was always acid and varied from .04 to .21% as Acetic acid, the average being about .1%, while the walls of the intestine were themselves alkaline. If the contents were hyperacid mucus was deposited on the walls and hindered absorption.

They assume that there is greater absorption from a meal of carbohydrates than from

a proteid diet in the stomach and intestines, from the character the food has on reaching the lower part of the small gut and they found that the unabsorbed nitrogen i.e. albuminoids, was equal to 5·34 to 6·78 % of the dry remainder in a proteid diet, to 4·69 % after ingestion of carbohydrates

There was never any pronounced putrefactive smell in the discharge and they believe that the acidity of the contents has an inimical effect on Bacteria; with only traces of H_2S, or methyl mercaptan, no indol, skatol, phenol, leucine or tyrosin, the amount of putrefaction is small. Acetic acid, some lactic acid, no free HCl, but some Ammonium Carbonate were present. 87·75 % of the Proteids of the food were absorbed by the stomach and the small intestine, and the remainder was not broken up by Bacteria until it reached the large intestine and became largely alkaline.

The Bacteria present seemed to be constantly changing and were slightly different after the different kinds of diet.

a. After a meat diet the following grew

1 A liquefying Bacillus, Bac. liquefaciens Hüi
2 A Bacillus like Bacterium Coli Commune
3 An oval non-liquefying Bacillus

These grew in large numbers.

4 An Ellipsoidal Bacillus
5 A large, plump Bacillus
6 A non-liquefying Streptococcus } not numerous
7 Yeasts
8 Moulds

All were facultative anaerobes, No 2 formed alcohol from sugar, coagulated milk and produced optically inactive paralactic acid. (Bacterium Coli Commune produces active.) No. 1 was very motile, with no spores, traces of alcohol in the media if sugar was present, also a little Acetic acid.

From a second meal in which proteids largely predominated two other Bacteria were grown

9. A short thick Bacillus with rounded ends Bacillus Lactis aërogenes.
10. A short rod Bacillus with flattened ends Bacillus Ilei, 2-3 μ long, 1μ broad.

No 9. produced a large quantity of alcohol from sugar. No 10 produced some alcohol from sugar with Lactic and Succinic acids.

6. From a Carbohydrate diet the following Organisms were separated out.

1. A Bacillus like the Bacterium Coli Commune
2. A non liquefying Diplococcus
3. A smaller non liquefying Diplococcus

These commonly

4. A liquefying Streptococcus, Streptococcus liquefaciens Uhlei
5. A slender rod-shaped Bacillus 5μ long, 1μ broad.
6. A large chain Bacillus
7. Yeast forms.

All facultative anaerobes. No putrefactive organisms present.

No 4. formed a small quantity of alcohol and a considerable quantity of lactic acid.

No 5. The Bacillus Gracilis Uhlei, produced alcohol. lactic and acetic acids. The Bacilli were motile and in pairs.

"Probably then if organisms act in the small intestine it is to form alcohol or the fatty acids.

Macfadyen also looks upon the fatty acids as the great antiseptics of the intestinal canal and attributes to them greater inhibitory power than even Hydrochloric acid itself.

The value of the second paper as regards my subject lies in the fact that all these organisms must have run the gauntlet of the Gastric juice unscathed and again the constant variation in the species found shows that members of different species are constantly passing down and that it is not due only to growth of organisms already resident in the small gut.

Further any pathogenic germ as Eberth's

Typhoid Bacillus which has escaped the dangers of the stomach has still to meet the fatty acids in the intestines.

Before closing the history of this part of the subject I should mention the work of Straus and Wurtz[153] who in 1889, using a dog with a gastric fistula, grew large numbers of several kinds of germs from the discharge, but if they kept the organisms in the same juice at 38°C for 4 days only a few hundreds grew, if for 8 days nothing grew.

A Bacillus Subtilis grown from the stomach of a sheep was still capable of reproduction after many days digestion, the spores being very resistant.

Tubercle Bacilli artificially digested for 7 hours were still virulent when injected, for 8 to 12 hours caused local abscesses only and after 18 to 24 hours were inert.

Anthrax was destroyed after thirty minutes, both spores and bacilli, while Cholera Bacilli had to be digested for 2 or 3 hours. These experiments were all made in vitro and are maximum results.

Part III

Description of Methods.

Chapter I.

Terminology.

Throughout this essay I have used one or two terms in a special sense, and it will be convenient if I here state their exact meaning.

Free Acidity : the presence in a fluid of any acid in an uncombined state, which gives all the tests of the pure acid, & which may be either one of the mineral or one of the organic acids.

Combined Acidity ; acid of any kind in a state of combination with Proteids ; the full name for it would be Organically combined Acidity.

Free Chlorine ; corresponds to the free acidity, and is free HCl.

Combined Chlorine ; corresponds to the combined Acidity.

Fixed Chlorine ; the inorganic chlorides, which remain after heating to a white heat.

Free and combined organic acids ; are the same as the above, applied to the organic acids.

Total Acidity ; the total amount of acidity in any given fluid, estimated by means of Phenolphthalein and a Caustic Soda Solution of known strength.

All acidities are calculated out in terms of Hydrochloric acid, and reduced to percentages. HCl is variously given as having an Atomic weight of 36·5 36·4 and 36·37, having regard to the

number of calculations I have had to make, I considered it sufficient if I took the Atomic weight as 36, so that all my calculations are subject to this error, which is, however, easily rectified if need be, by a proportion sum.

—"—

Chapter II.

Methods of estimating Hydrochloric acid.

Free. I principally relied on Günzburg's Phloroglucin-Vanillin test in judging of the presence or absence of free HCl, using now and then, the Resorcin test (cf p. 84) or Mohr's Sulphocyanide of Potassium (cf p. 84).

As a check on these tests I made use of a modification of Hayem and Winter's elaborate method, (cf p. 34) the occurrence of Liebermann's reaction, a violet colouration of the organic matter present, at the end of the evaporation, and the diminution in acidity and Chlorine at the same time giving me ample proofs of the presence or absence of the acid.

Combined. To arrive at an estimation of the Chlorine combined to organic matter, I estimated first, the total Chlorine in the fluid, without removing the Proteids, by means of a solution of Nitrate of Silver of which 1 cub. cent. represented ·01g NaCl or ·00624 HCl, expressing the result in terms of HCl per

cent. I then evaporated 5ccs. of the fluid at a temperature of 110° – 120° Cent. continuing the heat for about an hour after drying, or, and this method I found just as certain, I evaporated the fluid at 80° Fahr to 100° Fahr. leaving it for 24 hours. When thoroughly dry I added distilled water and again estimated the amount of Chlorine present, the proteids of course being the same as before. To make sure that all the free HCl had been driven off, a drop of this fluid before the chlorine was estimated was dried in a porcelain capsule with a drop of Phloroglucin-vanillin, and in every case in which this was done the reaction was negative. The first estimation of Chlorine minus the second gave the amount of free Chlorine present in the form of HCl. To find out then the amount of organically combined Chlorine I had only to determine the fixed Chlorine in 5ccs. which I did by calcining the solids from them in a capsule and testing as before. The combined Chlorine was represented by the total Chlorine present after evaporation minus the fixed Chlorine. The error in this process due to the presence of Proteids in the first two ~~process~~ analyses is so small that it may be practically disregarded, — As the following experiment will show. Some gelatine and the derivatives of the Gastric digestion of a considerable amount of fibrin were boiled with a solution of HCl, the resulting fluid was

yellow, contained no free HCl, had an acidity of ·684% and the Total Proteids in solution were 6·275%; i.e. the total acidity is 10·9% of the Proteids present. The total Chlorine, all combined and fixed was ·8736% of which ·0936% was fixed, the combined Chlorine therefore was ·78%. or ·096% more than the acidity. 6·275% of proteids then give rise to at most an error of ·096%, but the the total percentage of proteids rarely goes above 2· in the stomach giving an error of ·0307% at most.

Fixed; I have already given a short account of my estimation of the fixed Chlorine, suffice it to add here that in heating the capsule to get rid of the organic materials I took care to begin gradually to heat up the capsule and preferred to keep it at a dull red heat for a considerable period to raising it to a white heat at once, as by the latter method you lose a large proportion of the Chlorine.

Note; the solution of Nitrate of Silver used was standardised with an accurately made solution of pure HCl, and was made by dissolving 16·966 grs of $AgNO_3$ in 1 litre of distilled water. The indicator used was Bichromate of Potash in solution and the reaction was considered to be finished when the fluid then heated became a permanent brown colour.

Chap. III

Methods of estimating the Total Acidity, the combined acidity and the free Acidity.

Total Acidity; I obtained the amount of acidity present in a fluid by using a decinormal solution of Caustic Soda, and employing Phenol phthalein, 4% alcoholic solution, as indicator. In cases where extreme delicacy was required I used a centinormal solution of Caustic Soda.

Free acidity: this was obtained quantitatively in an identical way to the method used to estimate the amount of free Chlorine, the total acidity of a fluid being first determined and then the acidity after evaporation, i.e. the combined acidity, subtracted from it.

Combined Acidity; the acidity left after evaporation at 110° Centigrade of a fluid containing proteids, estimated in a similar manner.

The use of Phenol-phthalein as an indicator has lately been criticised by Mathieu [106-109.], who found that albumins, esp. acid albumin, peptones and leucin act on it. The action of these bodies is extremely slight, and, as they are regarded as being very weak acids themselves, is to be expected.

Chapter IV

Estimation of the organic acids

Qualitative; a. Lactic acid. I used Uffelmann's Carbolsferric test to detect the presence of this acid, but did not assume the certainty of its presence unless the colour struck on the addition of the fluid tested was a bright canary yellow.

b. Acetic acid. To detect this acid in a free state I relied chiefly on the smell produced by it when boiled with alcohol and a few drops of Caustic Potash or Soda, the smell of the Acetic ether produced being very characteristic. For corroboration however, I made use of Uffelmann's reagent, the coloration of the fluid, which I considered distinctive, being a dark orange brown. This colour however is given to the fluid by acetates as well as free Acetic acid, so that, if I could produce this colour with the second test, and no ether with the first I considered that acetates were present but no free Acetic acid.

c. Butyric acid; I used Uffelmann's reagent for this acid also, the slightly opaque yellow grey being quite characteristic. The smell of the fluid too gave corroborative evidence, as well as the smell of the Butyric Ether given off on boiling with alcohol and Caustic Soda, a smell which can be best compared to that of "pear drops."

Quantitative ; I did not consider it necessary to estimate the different organic acids separately, but could deduce the amount present from the procedure adopted in estimating the acidities and Chlorine.

For if the Total acidity be greater than the total Chlorine minus the fixed Chlorine, that acidity is necessarily organic. Again if the amount of free acid is greater than the amount of free Chlorine the difference must consist of the organic acids. While the same reasoning and deduction can be made in the combined acidity and combined Chlorine. Of course this argument applies to Stomach washes only when no other mineral acid, as HNO_3 has been taken by the mouth.

Chapter V

Methods employed in estimating the Total Solids, Ash, and Proteids

The Total Solids were estimated in the usual way. 5 ccs or 10 ccs of the fluid to be examined were put in a capsule, which had been carefully dried & weighed; the capsule was heated on a water bath until the contents were dry, heated again for half an hour in a hot air chamber at 110° Cent, cooled over Sulphuric acid and weighed. The results are given in terms per cent.

The Ash was weighed in the same capsule as the Total Solids, the capsule being heated carefully to a dull red heat, then after a time to a white heat, until the ash was white, then cooled over Sulphuric acid and weighed. The results are given in terms per cent.

The Total Proteids were obtained by evaporating 4 or 5 ccs of the fluid down to about half its bulk, adding a large excess of Absolute Alcohol and filtering through a dried and weighed filter paper. After washing the paper with alcohol and testing the filtrate for proteid with the Biuret test, — if there proved to be some remaining the filtrate was again evaporated down & precipitated with fresh alcohol — the paper was dried thoroughly at 110° Centigrade, cooled over Sulphuric acid and weighed. The filtrate was generally used to

estimate the amount of Sugar present, by means of Fehlings Solution.

Acid Albumen. 5 or 10ccs of the fluid were taken and neutralised carefully with decinormal Soda solution — a drop of the solution of Phenol-phthalein added to the flask aids greatly in enabling the operator to perceive, by the time the colour on addition of the Soda persists, when the fluid is nearly neutral. — if sufficient acid albumen fall to enable it to be weighed it was caught on a weighed filter paper and washed with distilled water. The paper was then dried, cooled & weighed as before.

Albumen. The filtrate from the foregoing was acidified with Acetic acid and boiled, if the precipitate did not fall kindly a drop of a saturated solution of Acetate of Soda was added as the boiling point was reached. The precipitate was washed with boiling water and with alcohol on a weighed filter paper, and the amount present estimated as before.

Albumose. If the filtrate from the last was of considerable amount it was evaporated down to smaller bulk and then saturated with Ammonium Sulphate 180.
and left for 24 hours. The precipitate was then filtered off and washed with a Saturated solution of Ammonium Sulphate three times and dissolved by warm water. This was then put in a dialyser and dialysed for 5 or 6 days, until no trace of

Ammonium Sulphate could be detected on the addition of a boiling aqueous solution of Barium Hydrate. The contents of the Dialyser was then evaporated down over a water bath, precipitated with alcohol caught on a filter paper and weighed.

Hetero-albumose. To obtain this form of Proteid pure, I saturated the fluid containing it with salt, after removing the albumens + acid albumens after 24 hours filtered and washed the filter with saturated salt. Placed the contents of the filter in a dialyser and after some days again filtered the contents. The increase in the weight of the filter paper was due to Hetero albumose. By on concentrating the filtrate further on a water bath a precipitate appeared this also was added to that on the filter paper.

Proto-albumose; the filtrate from the last after the Hetero-albumose had been removed, was dried and weighed.

Deutero-albumose; that part of the fluid which was saturated with salt but passed through the filter paper was placed in a dialyser for 5 days or so, then evaporated down, precipitated by alcohol and weighed.

Dys albumose; part of the Hetero-albumose precip-itated with alcohol became insoluble in warm solutions of acids, and could be caught on filter papers and washed.

Peptones; I know of no method by which the Peptones can be estimated quantitatively with absolute accuracy. I have either arrived at a conclusion by subtraction, knowing the total Proteids and the amounts of the other varieties, or I have used a method which, although it does not give absolutely accurate results, has given an indication, tolerably correct, of the amount present. My method is the following. Take the fluid that filters through after saturation with Ammonium Sulphate and add a solution of Tannic acid until a precipitate ceases to fall. Catch this precipitate on a filter paper and wash with saturated Ammonium Sulphate. Dry the paper thoroughly at 110° Cent. then wash four or five times with distilled water, again dry and weigh. The difference of weight in the filter paper before and after corresponds very closely with the amount of Peptone present.

In illustration of this I performed the following experiments.

Experiment I. To a solution of pure peptone, — obtained by dialysis from an artificial pancreatic digestion, — in distilled water, I added a few drops of a solution of Tannic acid. No precipitate occurred, even after some hours, or after adding Tannic acid to excess. A green colour usually formed from a trace of Iron in the fluid, but no precipitate. A solution was then made-up of ·0375 gr. of this peptone

— which had a bitter taste, fizzed on the addition of water, gave a strong Biuret reaction, but no precipitate with Ammonium Sulphate, — with 30 ccs of distilled water and divided into three equal parts to each of which 10 ccs of a solution of Ammonium Sulphate were added, to No 1, 10 ccms of a saturated solution, to no. 2, 10 ccs of a half saturated, & to no. 3, of a ¼ saturated solution. A few drops of a solution of Tannic acid were added to each — care being taken not to add excess, as the precipitate falls on addition of a small quantity but is redissolved in excess, — a precipitate fell in each case, more plentiful in 1 than 2, & in 2 than 3. The precipitate was caught on weighed filter papers dried and weighed. These weights however, only correspond to the strength of the Ammonium Sulphate solution. The papers were now washed with water, an equal amount in each case, again dried and weighed. The resulting weights were ·019 gr., ·005 gr., & ·001 gr. after the weight of the filter paper had been subtracted. The original quantity in each was ·0127 gr., so that the first is a little over, and the other two much under the original amount, varying with the strength of the Ammonium salt used. The error in no 1 was due to insufficient washing. On examining the filtrates from the three, by further saturating with Ammonium Sulphate and adding Tannic acid

a very slight opacity appeared in no 1, no 2 became opaque, while there was a marked precipitate in no 3.

That is to say then that, <u>though pure peptones</u> — contrary to all the text books, see Halliburton, Foster etc — <u>are not precipitated by Tannic acid, when they are dissolved in solutions of neutral salts they are precipitated by that reagent in direct proportion to the strength of the salt solution used</u>.

Tannic acid has no action by itself on either Ammonium Sulphate or Chloride of Sodium.

Experiment II.

Recognising the weak point in the above, namely the washing through the filter paper of part of the precipitated peptone, I sought a means of saturating the solution with some neutral salt, which did not contain Ammonia, so that I might perform a Nitrogen estimation of the precipitate by Kjeldahl's method.

Instead of using Sulphate of Ammonium, I tried solutions of Common Salt, and Tannic acid, but though the precipitates fell in direct proportion to the saturation of the NaCl solution, yet the densest precipitate penetrated all kinds of filter papers, even after boiling or boiling + Acetic acid.

Experiment III.

I used Magnesium sulphate in like

manner. This did very well, a solution of peptone saturated with this salt and precipitated by a drop or two of Tannic acid, giving no reactions for proteid when filtered. The N was then estimated by Kjeldahl's method and from it the value of the peptone determined.

·591 gr. peptone used, with the ash subtracted = ·483 gr, no other proteid present, no precipitate on saturation with Ammonium Sulphate, or on addition of Tannic acid.

20 ccs of water added and Magnesium Sulphate to saturation, then ·5 cc of a saturated solution of Tannic acid added, the precipitate caught in a filter paper and dried.

The filter paper then digested in boiling Sulphuric acid and the Nitrogen estimated as usual in Kjeldahl's method,

The difference in the acidity after absorption of the NH_3 distilled over corresponded to ·08761 gr. NH_3, that is ·07215 gr Nitrogen; or equal to ·481 gr of Peptone

That this method is correct I am convinced, but I have not had time to work at it further, later I hope to devote some attention to the question.

With regard to the precipitation of Peptone in the presence of Ammonium Sulphate, the first

method I have described, in many of the observations on the course of digestion which I have detailed in Part IV, further on, I made use of it and found that, although not absolutely reliable, it was fairly correct, and I was able to correct the results, by estimating the total proteids or total organic solids, then by subtraction get an idea of the amount of peptone present. As a rule the quantity obtained by the Ammonium Sulphate and Tannic acid method was within a few milligrammes of the amount shown by subtraction.

Pure Peptone

When I wished to use pure peptone I made use of the following procedure; having, by means of an artificial digestion, made a considerable quantity of albumose I separated it out in a pure state. I then put it inside a parchment tube with pepsine and HCl outside, digested it for some time, evaporated the fluid outside to a syrup, precipitated the contained peptone with absolute alcohol filtered, washed several times with alcohol, dried over steam and then over Sulphuric acid. The proteid so obtained did not precipitate in a boiling saturated solution of Ammonium Sulphate, or on addition of Tannic acid unless some salt were added as

well; it was of a slightly yellow colour, lighted on the addition of water and was hydroscopic.

Chapter VI
Digestive Power

This I tested in the usual way, adding small shreds of fibrin to the fluid, with or without the addition of a small quantity of pepsine. In some cases I made use of Grützner's method, staining the fibrin before-hand in a carmine solution and keeping it in half water, half methylated spirits.

In testing the power of the combined acidity on the amylolytic power of the Saliva, I used a filtered solution of my own saliva, and some starch paste made with hote water before-hand.

Chapter VII

Other

Methods of testing for acids etc.

I wish here to make a few observations on those tests which are often used or have been recommended but which I have discarded in favour of those catalogued above.

Also to make a note of the delicacy of the tests with their fallacies.

The colour tests may be divided as follows.

a. Reagents which reveal the presence of acid of any kind.

1. Phenolphthalein 2. Congo Red. 3. Eosin.

b. Those Reagents which react to free HCl more especially.

1 Methyl violet
2 Gentian violet.
3. Smaragd grün
4. Malachite green
5. Vert Brillant.
6. Tropaeolin OO (Dimethyl orange Orangé Poirrier).
7. Benzo purpurin.
8 Phloroglucin - vanillin. (Günzburg)
9 Resorcin and Sugar (Boas)
10 Sulphocyanide of Potash (Uffelmann.

c. Those reagents which are of use in diff-

<u>Differentiating the organic acids</u>

1. Carbolo-ferric . Uffelmann.
2. Alcohol and Caustic potash.
3. Ether.

a.

1. <u>Congo red.</u>

This is a test of extreme delicacy, and may be used as recommended by Riegel[129] and Schäffer[141] in the form of Congo red papers. The reagent itself, a dark red stickling a deep blue in acid solutions, was first discovered by Böttcher in 1884.

By means of it ·002% of acidity can be detected, (Krukenberg[90] quoted by Boas). If the acidity be pure HCl as little as ·001% can be estimated. ·3% Lactic acid however obscures ·1% HCl so that it is of little value in differentiating the different acids especially at present when we have more certain methods of calculating how much free acid and of what kind is present.

I do not know how this reagent behaves in the presence of combined HCl, but a priori would suppose that it reacts as with the free.

2. <u>Corin</u>

Lately recommended by Jolles[172], it does not fluoresce in acid solutions, a property which belongs to it in alkaline and neutral ones. It does not

differentiate between acids and altogether seems a poor reagent.

I have no experience of it.

6.

1. Methyl violet.

This aniline colour becomes blue on the addition of pure HCl, but the exact point is difficult to determine if the acid be small in amount; it is therefore of little use as a quantitative test. As I have said before I consider every test which relies on the change from one colour to another, unless, as in congo red, the change be exceedingly striking, as misleading and very difficult to manage.

It has been advocated by S. Klemperer[86], Van der Velden.[161] Boas[4] and Lee[16] use it in this way. Two equal amounts of the reagent are put in two glasses and placed close to one another, pour in filtered stomach fluid into one, comparing the colour with that of the other which should be diluted with the same quantity of distilled water.

Lee gives .018% as the limit of accuracy Boas .02%, in estimating HCl. For lactic acid .3% is the limit. Kast recommends the precipitation of the proteids with Tannic acid before -

-hand, this however can not be exact as neither the peptones or deuteroalbumoses are totally precipitated by Tannic acid, unless some acetic acid be present, or some neutral salt.

Healy recommends, if the proportion of acid be very small, that the fluid to be tested should be evaporated to small bulk over a water bath, the methyl violet added & further evaporated to one or two drops. This procedure, he claims will detect by the change in colour as little as .0003 gr Hcl.

2. Gentian Violet and Fuchsin

Similar to the last and of far less sensitiveness, of little utility.

3. Smaragdgrün.

Introduced by Van Jaksch becomes grey or yellow green on the addition of acids. Shows .04% Hcl (Krukenberg) .048% Hcl (V. Jaksch) Boas says that it is sensitive to free Hcl but also to the organic acids, therefore of little use.

4. Malachitgrün (Malachite green)

Hoster has got good results from this colour, detecting .04 to .05% Hcl, and finds that lactic acid 10% does not change its colour.

5. Vert Brillant Emerald green.

Investigated by Lannois[176] and Lépine[177] who found it to be a blue green even in very dilute solutions. If a drop or two of this reagent be added to a ·0187% HCl solution, the mixture becomes green (Roos,) a stronger HCl gives a yellow colour. Lactic acid only in ·3% causes a green coloration, in no concentration brings out the yellow. Georges says that it is better than methyl-violet, while Kruthenberg on the other hand does not recommend it.

It has been said not to be affected by combined acidity.

6. Tropeolin 00

Introduced by van der Velden, is an orange coloured fluid, which becomes a muddy violet on addition of acid, free acid, that is.

Roos uses a tropeolin paper and says that it is as good a test for free lactic as free HCl, but if the reagent be used by evaporating a mixture of it and the fluid to be tested in a small evaporating dish slowly over a small flame, the edges on drying take on a lilac or bluish colour, which is also distinctly characteristic of the presence of a mineral acid. No organic acid gives a like colorization.

Danilewski modified the procedure by only drying a drop of the reagent and of the fluid together at a not too high temperature, or dryness the characteristic colour appears.

Tropaeolin is subject to the objection that strongly coloured itself the moment of change is difficult to determine. It gives, notwithstanding Boas' warm recommendation, very uncertain results.

Sensitive to .006 g. HCl.

7. Benzopurpurin, 6B.

Lately recommended by v. Jaksch, who could detect .00039 g. HCl in 6 ccs of water, and therefore is more delicate than Congo-red. It may be used in the form of Benzopurpurin papers which turn on an intense black blue if the stomach wash contains .4% HCl or more, a greater dilution of the acid causes the dark red of the solution, or paper, to become light violet. Organic acids form a brownish violet. If both HCl and organic acids be present and the paper is of a brownish black tint shake it up with Sulphuric Ether the colour due to the fatty acids disappears.

Peptone and serum albumen are said to have no effect on it, nor have the acid salts.

9a. One or two other reagents have been suggested as for instance

Ultramarin and zinc sulphide, suggested by Healy and employed by Kahler[174] and Kraus[175].

Ultramarin is decomposed by free acids in general even in dilute solutions, H_2S being given off, silicic acid and sulphur deposited.

Zinc sulphide is similarly decomposed.

The method is as follows (v Jalloch.) Place the fluid to be tested with some ultramarin, sufficient to give it a blue tinge. Warm in a waterbath. If HCl be present, the blue has changed to brown, and a strip of paper soaked in acetate of lead will have become black, if placed before hand in the dish.

The happens with the Zinc sulphide

"The reactions do not lend themselves to any practical use" (Leo.)

Vegetable colouring matters.

Uffelmann[159 160] has employed the colouring matter of claret as a test. Broschfield[161] has got good results from it.

Uffelmann has also used a solution of the colouring matter of bilberries with good results.

These methods however are more of the nature of curiosities than of real service, as the colouring solutions have to be made up fresh each time, the colours of solutions not keeping.

8. Phloroglucin Vanillin, Günzburg's[168] test.

made up of

Phloroglucin	2.
Vanillin	1.
Alcohol absol.	30.

Is extraordinarily delicate if used in the ordinary way, i. e. a drop or two of the reagent mixed with an equal amount of the stomach contents in a porcelain dish and heated carefully to dryness, a bright carmine red, appearing just at the edges, denotes the presence of a free mineral acid. Care must be taken not to burn the mixture. There are some fallacies which I return to later. Mineral acids combined with albuminoids, unless in great concentration, comparatively speaking. (·48 – ·642 %) do not give this bright colour. Even when concentrated the colour which appears at the edges is more of a brown red than a carmine. Lactic acid, Butyric acid and Acetic acid give this colour in no concentrations.

Boas recommends as usual the use of papers dipped in the reagent and dried. But he also states that the solution made up in the following way is more delicate

Phloroglucin	2
Vanillin	1
Alcohol (80 %)	100.

This reagent is said by Leo to be able

to detect as little as ·004 % Hll. in a watery solution.

9. Resorcin

Formula Resorcin 5 Gr.
White Sugar 3 Gr.
Add Dilute Alcohol to 100 cc.

Boas [36] introduced this reagent, which is used in a similar manner to the preceding a little more of the fluid to be tested than reagent being used. On drying with mineral acids present in a free state a more scarlet red and not such a bright one is formed, which fades slowly on cooling. The same precautions must be observed. Is not quite so delicate as Günzburg's but is useful as a control. May also be used as papers.

Shows ·006 % Hll. in watery solution.

10. Sulphocyanide test.

Mohr's test is the latest of the number and is formed as follows

Solution of Sulphocyanide of Potash (concent.)	4 pts
Solution of Acetate of Iron. (concentrated)	1 pts
Water	20 pts.

It is used as follows; place some of this fluid in a porcelain dish and run several

drops of the fluid to be tested down the side at the point of contact a dark brown ring forms if free HCl be present. Is not disturbed by salts, and only by a great excess of proteids. Ewald finds it less sensitive than either of the preceding. Detects ·1% HCl.

(Another test used by Mosler is as follows To the contents to be tested a solution of iodide of Potash and Starch paste is added, then a few drops of a very dilute solution of ferric acetate, if free HCl be present, a blue colour appears, unless phosphates are also present when the test is uncertain.)

With regard to the tests already stated their comparative delicacy has been investigated by many, Ewald and Leo among others.

It will be well if I give their results

1. Ewald

	Give a Positive Reaction in presence of			The reaction fails in a mixture of HCl or Lactic acid with equal parts of solution of			
	1. HCl %	2 Lactic Acid %	3. Butyric %	1. Pepsine %	2. Lactic acid %	3 Salts %	4 Starch %
Methyl violet	·024	·4	·5 - ·6	·5	–	5 - 10	·5
Tropaeolin	·03	1. +	1. +	·5	–	5 - 10	–
Smaragdgreen	·04	1.	1. +	·5	–	5 - 10	–
Congo red	·01	·02	·04	·03	–	1 - 8	1.
Günzburg	·005	–	–	·03	? –	–	–
Mosler	·1	–	–	1·2	·10	–	–
Uffelmann	–	·01	·05.	–	·05	·2 - ·25 Salts HCl	–

That is to say that Günzburg's reagent is the

most sensitive in nearly all respects, then the Congo red.

Mohr's reagent is much less sensitive.

2. Leo

Substances in the Solution with Hcl.	Percentage of Hcl, by which a reaction occurs.						
	Congo red.	Congo paper	$CaCO_3$	Resorcin	Günzburg	Methyl Violet	Tropaeolin.
Water	·0009	·01	·002	·006	·004	·018	·006
Phosphoric acid	·008	·02	·008	·09	·03	·09	·08
(acidity = 1% Mohr)							
Albumen (1 in 200 water)	·02	·05	·002	·08	·05	·1	·2
Peptone 2%	·08	·1	·002	·16	·16	·16	·18
Bread and Water	·014	·03	·003	·03	·03	·07	·04
(20 gr in 200 ccs)							
Nacl 1%	·0018	–	·003	·0037	·007	·058	·007
Grape sugar 1%	·0009	–	·007	·007	·007	·037	·007
Starch paste 2%	·0056	–	·003	·011	·007	·019	·019
Whey	·08	·17	·007	·17	·17	·17	–

Leo on the other hand gives Congo red as the most delicate, and following it the carbonate of lime that introduced by himself and noted on page 33 of this essay.

Of the substances used with the Hcl albumen and whey will be seen to be the substances which obscure the reactions most, although some of the values given seem to me to be placed too ~~high~~ low, as for instance, the values placed on

the peptone experiments. Without peptone by the Phloroglucin Vanillin test ·004 % can be detected, with peptone (2 %) ·16 % only, a difference of ·156 %. or a proportion of acid to peptone of 7·8 %, this seems to be too small. (4 p. 251)

Again the ·5 % albumen makes a difference of ·046 % or a proportion of acid to albumen of 9·2 %, more than that obscured by the peptone, which I do not regard as correct.

The following Table from Günzburg[168] is of interest here

Substance Tested.	Phloroglucin-Vanillin	Indol-Vanillin	Resorcin-Vanillin	Boas' Resorcin.
HCl.	Scarlet red	Rose red	Red violet	Scarlet red
Delicacy	·01/90 mgr HCl	1/90 mgr.	1/80 mgr.	1/80 mgr.
Lactic.	–	Dull red	Slight red	Sometimes red.
Glaubersalz	Green or yellow	Green or doubtful red	reddish, or violet or none	do.
Glaubersalz and acetic acid	Yellow brown red or burning	Red	Violet	do.
$CaCl_2$	Evanescent dull red	Rosy	traces of red.	Nil.
$CaCl_2$ and Acetic acid	Powerfully red	Red	Slight red violet	Transient red.
Sodium Acetate	Green, sometimes red	Green	strong red violet	strong Scarlet
Sodium Acet. and Lactic acid	Rose red	Green	strong red violet	Scarlet
Sodium Lactate	Red. Yellow Red brown	Green	Red violet	Red violet
Sodium Lactate and Acetic acid	Red to red brown	Green	do	do.

From this table it is seen that a considerable number of substances give rise to reddish discolouration of these reagents substances. (Indol - Vanillin and Resorcin - Vanillin are only modifications of the other tests.) Günzburg sums up the significance of these as follows. 1. The group of inorganic salts, except $CaCl_2$ all give varying red colours but have no significance for the clinical testing as every stomach contains hall, yet every stomach wash does not give a red colour.

2. Of more importance are the group of organic salts with aganic acids added, and for these Resorcin - vanillin, and Boas' reagent are the most delicate.

3. $CaCl_2$ alone or with organic acids. If the colour be from pure HCl it disappears after heating to dryness for some time, that due to $CaCl_2$ does not.

He concludes that the Phloroglucin - Vanillin is the best of the four.

I performed some experiments with regard to the delicacy of the Phloroglucin - Vanillin, the Resorcin and the Sulphocyanide tests

Experiment I. HCl. %

	·054	·0298	·027	·0152	·0108	·0072
Phloroglucin - Vanillin.	+	+	+	+	+	+
Resorcin.	+	+	+	±	—	—
Sulphocyanide	+	+	+	+	±	—

I used 5 cc's of the HCl solution and dried a drop or two of it with the first two, pouring the remainder gently into a solution of the latter.

+ signifies presence of reaction

Günzburg's reagent was the only one which showed the last dilution. The Resorcin failed before the last of Mehis's test

Experiment II

A mixture of water, bouillon and gelatine was made, some HCl added, and the fluid left for some hours.

On examination it was of .108% HCl acidity and did not lose any on evaporation, nor was there any Liebermann's reaction.

It was tested carefully by means of the following reagents.

1. Phloroglucin-vanillin gave a slight red-dish brown, no bright scarlet or crimson.
2. Resorcin a light yellow colour
3. Mehis's test, gave no reaction
4. Uffelmann's Carbolo-ferric solution was decolorised, the violet however was replaced by a brown colour, darker than the solution added and thatn that formed by the addition of acetic acid.

The addition of a very small quantity of Lactic acid obscured the last reaction.

Experiment III.

A solution of HCl ·0252% was made and 1% peptone added

	HCl %.		
Vanillin-phlor.	+ ·0252%	+ ·018%	+ ·01026%
Sulphosyanide	+ "	+ "	— "
Resorcin	— "	—	— "

More peptone was then added to the solution and the phlorophucin-vanillin also failed, giving a yellow brown colour.

Resorcin then is not nearly so delicate as phlorophucin-vanillin in the presence of peptones, and Mohr's reagent is less delicate than Günzburg's but about Boas'.

Experiment IV

I tried the effect of <u>Tartaric acid</u> on the three, as I had incidently found that a red was formed by it on Günzburg's reagent.

A solution of this acid, which is dibasic, ·3% was made, then stronger solutions:

Result	Vanillin.	Resorcin	Mohr's.
·3%	—	—	No content reaction. Light yellow colour.
·70926%	+ light red.	—	— light yellow
2·025%	+ pink becoming yellower	—	— yellow
45· %	+, yellow on further heating	+ pink, brown after	— yellow, disappearing

Tartaric acid then does give a bright pinkish red with Giungtrey's reagent, but only in considerable concentration, neither the Resorcin or the Sulphocyanide of potassium show any decided change.

Sansoni[139 >61] and Modinaci in a paper, reported by P. Giacosa, have tabled experiments on different acids, a note of which may be of use here;

Acid.	limit of delicacy of Reagents.					
	Methyl violet.	Turpentine	Congo	Mosher	Giungtrey	Boas.
HCl	·0072 gr	·00018 gr	·00031	+	+	+
HNO_3	·0126 gr	·00031	·00024	+	+	+
H_2SO_4	·0147 gr	·00024	·0018	+	+	+
$C_2H_2O_4$	·0315	·0063	·00472	±	+	+
H_3PO_4	·01956	·00032	·00024	±	±	±
$C_4H_6O_6$	-	·0015	·00056	±	-	±
$C_3H_6O_3$	-	·00226	·00067	±	-	-
CH_2O_2	-	·0025	·00034	±	-	±
$C_6H_8O_7$	-	·0035	-	-	-	±
$C_4H_8O_2$	-	·0176	·0035	±	-	-
$C_2H_4O_2$	-	·03	·0003	±	-	-
$C_7H_6O_2$			·0061	-	-	-

The latter three were used with decinormal solutions of the various acids, + means distinct reaction (Reazione intensa), ± less distinct (reazione sensibile), ± indistinct reaction (reazione leggiera sensibile), - Reaction absent.

From this table it is seen that, in the hands of these experimenters Tropaeolin proved the most delicate of the first group, followed closely by Congo red, of the second group Günzburg as usual was more delicate than the others, in that it responded like them to decinormal solutions of mineral acids, but did not react to solutions of the organic acids.

On the whole then Günzburg's test is to be depended upon as one of extraordinary delicacy and trustworthyness, and I prefer it to the others and always use it. A very delicate way of bringing out the distinctive colour is as follows; put a few drops of the reagent on a porcelain capsule and dry them so that a thin layer of the dried reagent be spread over the surface of the dish. this may be done by gently moving it up and down while over a flame, taking care not to burn it.

Now with a glass rod dipped in the fluid to be tested make a streak across the surface of the dried reagent. Dry this very carefully, as the edges dry the characteristic red colour appears if there be any free mineral acid present.

The Resorcin test can be used in the same way; by this means I have been able to detect as little as .0027% HCl.

It must be remembered that with these two tests only a drop or two are used, and that they

are therefore of use when there is only a small quantity of fluid available for testing, and again that if the fluid be exceedingly weakly acid evaporation of 10cc to dryness may give a reaction, while .25cc gives none; the amount of acid of course in the one being 40 times greater than in the other.

Of almost as much importance as the impairment of the accuracy of the tests by the presence of albuminoids, is that due to the presence of organic acids along with the Hydrochloric.

To this subject I have devoted a little attention, with the following results.

I do not need to give particulars of the experiments.

I tested solutions of HCl in water and also solutions of HCl of the same strength but which also contained Lactic or acetic acids.

Lactic acid up to .4% had absolutely no influence on the delicacy of Günzburg's reaction. .01% HCl was distinctly noted. When solutions of 1% or higher were used, however, although the higher percentages of HCl were still clear, yet the finer distinctions were lost.

The same applies to acetic acid.

Chapter VIII

Methods employed in the cultivation of Bacteria from the stomach contents.

To procure the organisms I proceeded as follows:—

I sterilised some test tubes in the usual manner; first by washing with water, then with methylated spirit; secondly by heating them in a hot air chamber, after carefully plugging them with cotton wool, at a temperature of 150° Centigrade for an hour.

The patient, whose stomach wash was to be tested, was then asked to pass the stomach tube. This had been carefully cleaned and rinsed with alcohol. After the end of the tube was in the stomach, the patient was requested to strain, while the free end of the tube was depressed.

The first few drops that escaped were allowed to fall into a pail, then the plug having been removed from one of the sterilised test tubes, a small quantity of the fluid was caught in the test tube and the plug quickly replaced.

With the material to hand, I proceeded to inoculate some tube plates.

These were generally made with gelatine of the usual strength.

Warming the gelatine sufficiently to melt it I inoculated it with a small drop of the stomach contents by means of a platinum needle, which had been previously sterilised by heating to a white heat.

Then I distributed the gelatine over the inner surface of the tube by constant rotation under a tap of cold water.

In most cases, however, before solidifying the gelatine, I made a second dilution, and often a third in the usual manner; removing a portion of the first, after thorough mixing, and inoculating the second with it by means of the platinum needle; and so for the third.

The tubes were kept at a temperature just low enough to prevent the gelatine from dissolving. When any colonies had grown, ordinary gelatine tubes were inoculated, both by the puncture and the streak method.

The method of growth in this medium having been observed, tubes of agar-agar, bouillon, milk or potato were inoculated from it in turn.

The gelatine, agar-agar and bouillon used were prepared in the way recommended by Koch, 1% commercial peptone being added to each. The reaction of each was slightly alkaline or neutral.

After filling the sterilised test tubes

with the above and plugging them again, they were sterilised in a Koch's steam steriliser for twenty minutes on two or three succeeding days. They were used after a day or two had been allowed to elapse to guard against the occurrence of any foreign growth.

The milk used was sterilised by boiling for $\frac{3}{4}$ hour every day for four or five days. The tubes, containing it were then set aside for some time, if no change occurred they were used.

The potato tubes were made as follows;- the potatoes were well washed and then, solid cylinders cut from them with an ordinary cork borer, and cut of a size almost to fill the test tube. One surface then, of the piece of potato was cut off obliquely, a small bit of wadding placed at the bottom of the tube with a drop or two of distilled water, the piece of potato placed on the wadding and the tube plugged. The tubes thus made were sterilised in the steam steriliser for an hour every day for four days. A fortnight was allowed to elapse before the tubes were inoculated to make certain that they were sterile.

The solution of glucose used was about 5·%, and the tubes filled with it were sterilised for a hour in the steam steriliser.

The Anderson bouillon tubes were made as follows. Some pure olive oil was made

absolutely sterile in the steam steriliser by repeated heating. It was then kept in a plugged flask. Sufficient of this was added to the bouillon tubes as required by means of a sterilised pipette. The flask with the oil was then plugged again and boiled. As a rule about 1 to 1·6 cubic centimetre was poured on the surface of the bouillon. All air was then excluded.

All these tubes were kept at a certain temperature by means of a hot air incubator.

The bouillon, milk and potato tubes were generally kept at 38° Centigrade, or the body temperature.

In some cases I found it somewhat difficult to get any organisms to grow on gelatine plates, so I used agar-agar tube plates for the same purpose. I found after that two American bacteriologists[72] recommend a similar procedure.

The agar-agar used, contained both agar-agar and gelatine. It kept solid at 40° Cent, but if previously liquefied by boiling it remained liquid at 40°. See Sims Woodhead, Bacteria and their products p. 392.

In making plates of this substance I just liquefied an ordinary agar-agar tube by boiling, then cooled it down to 40° Cent

in the incubator. While it was still fluid I inoculated it from the specimen I wished to test. Then placing it under the tap, I soon by a rotatory movement distributed the material over the sides of the testtube where it solidified. I could now put it in the incubator at 38° to 40° (centigrade without it's dissolving again.

By this means I was enabled to grow the organisms from the beginning at the body temperature. This is a great advantage in dealing with the organisms of a viscus like the stomach.

The motility of the organisms was investigated by means of a drop of a broth cultivation suspended from a glass slide, on which had been cut a slight depression. In fact by the hanging drop method.

In staining the organisms I made use of a saturated aqueous solution of methylene blue, which unfortunately is not permanent, or an alcoholic solution of methyl-violet.

For immediate staining the first is the most handy, because any excess of stain can be washed off, but as I said before it is not permanent. The second unfortunately often over stains the specimen, half a minute to a

minute being the maximum time usually allowed.

All the specimens were stained as dry films on cover glasses and subsequently mounted in Canada Balsam.

For the experiments on digestion in which a considerable quantity of material was required, the organisms were grown in bulk in bouillon in sterilised flasks. The requisite quantity for each experiment was removed by means of a sterilised pipette and added to the contents of the dialysers.

Part IV.

Experiments on Digestion.

Artificial and natural.

Chapter I.

A. The course of the different acidities in artificial gastric digestion.

While experimenting on the behaviour of certain micro organisms to acids I had occasion to use a dialyser inside which I placed nutrient material, with solutions of HCl of various strengths outside. I was at once struck with the fact that the fluid inside not only became equal in acidity to the fluid outside but soon greatly surpassed it, although at the same time the acid solution inside did not affect micro organisms so deleteriously as a solution of HCl of similar strength. On further investigation I was convinced that the Hydrochloric acid, which was used outside, on dialysing through seized hold of the proteids in solution, combining with them to form some definite chemical body and that this body was of the nature of a compound acid. And again I found that, although this compound acid had almost if not absolutely the same acid equivalent as pure HCl, with regard at least to its action on Phenol-phthalein, its presence inside the dialysing tube did not prevent more pure HCl from coming through. Shortly after I had noticed this fact I found that Hayem and Winter in their book Du Chimisme Stomacale had worked at the same matter especially with regard to Human peptic digestion, and that Ch. Richet, [128] Villejean

for, in artificial peptic digestion at least, if there is a highly albuminous material to digest in a flask, and a strong solution of HCl be added the action of the pepsine is hindered, while if a weak solution be used there is probably not sufficient acid present to satisfy all the affinities of the Proteids and digestion is not complete.

Experiment 1. This is a simple experiment performed without the use of pepsine. Some 10% gelatine was placed inside a dialyser, with a solution of ·612% HCl outside; the gelatine had a slight acid reaction ·018%. Next day the acidity inside, as may be seen in the Chart, was ·72%, while the day after it had fallen to ·684%. The acid outside fell slightly the first day and a little more during the second, down to ·576%. On the third day the acid solution was siphoned

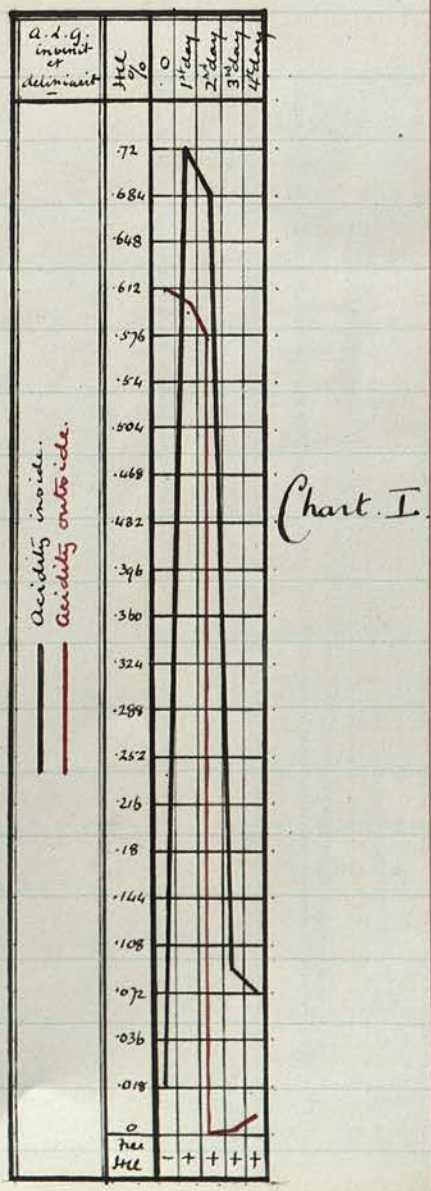


Chart. I.

off and water substituted when at once the acidity inside fell, reaching in 24 hours .09% and in 48 hours .072%. The note below in the lowest division of the chart shows the presence or absence of pepsin.

Experiment 2. I then performed a very similar experiment in a different manner, especially to show the behaviour of HCl in dialysing through into a. pure water b. a proteid solution.

Chart II shows the course of the acidities very well. In both cases the acidity outside was .612% HCl, for the first 24 hours and then as before the acid solution was siphoned off and pure water substituted. It will be seen from the curves that the acidity in the second case increased more rapidly and went higher than in the first and did not become equal to the outside acidity. And also that on withdrawing the acid solution outside it did not fall almost to zero as in the first. Analysis of the fluid taken from the dialyser at the end of the second experiment showed

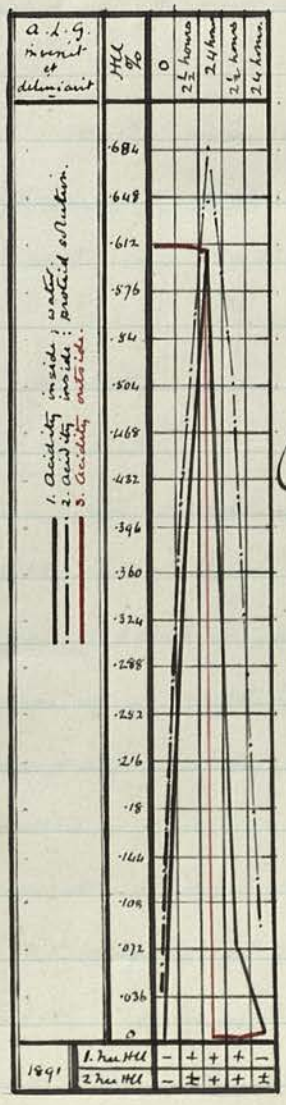


Chart II.

the presence of chlorine, but no free HCl; it gave a faint Biuret reaction and decolorised Uffelmann's Carbolo-ferric reagent, changing the violet into a brown yellow colour.

The amount of HCl solution outside in this experiment, as in the last, was 3000 ccs; excess being used so that the acidity outside might remain fairly constant, the amount of acid taken up inside being very small compared with the total outside.

Experiment 3. a. 20 ccs of a 1·04% HCl Solution were placed in a parchment dialyser and surrounded with tap water.

b. 20 ccs of a 1·04% acid solution, made up of beef broth, gelatine and HCl were placed in a similar dialyser with tap water, 3000 ccs, round.

In an hour a. was ·54% acidity

b — ·684% acidity.

While in 24 hours a.'s acidity was too small to calculate out, while b's was still ·063%.

Experiment 4. 20 ccs of a glucose solution were placed in a dialyser with 3000 ccs of a ·576% sol. of HCl round, next day the acidity inside was ·567, while that outside was the same.

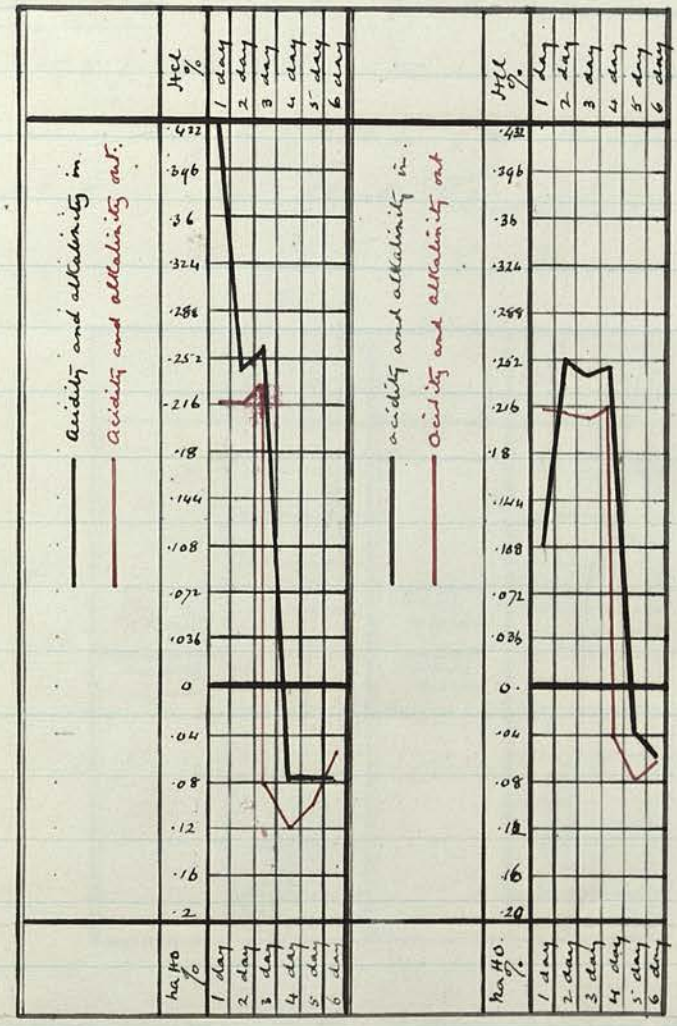
Experiment 5. In this experiment I used the filtered stomach wash of a patient Hodgson (cf. p) placing 20 ccs of it, of ·48% acidity, only a trace of which was free, inside the dialyser tube with 3000 ccs

of a ·216% solution of HCl wound. Next day the acidity inside had fallen to ·243%, that outside was stationary while on the third day the acidity of both had risen a little. The fluid outside gave a very faint Biuret reaction. On the third day a sol: of Carbonate of Soda was substituted for the acid and the experiment continued for three more days. The fluid inside rapidly became alkaline and on the third day was slightly more alkaline than the fluid outside. The whole was kept at 40° Centigrade during the experiment, and a pinch of Pancreatine was added to the contents of the dialyser during the second half.

Experiment 6. A few days after I obtained some more of Hodgson's stomach wash, which was again filtered and the acidity determined. This was found to be ·108%, the total chlorine being ·09%, while there was no free HCl present. I performed a similar experiment to the last, and it will be noted that here the acidity inside rose above the acidity outside, which was again ·216%, and continued slightly above it, while on substituting an alkali for the acid outside the alkalinity became equal. See Chart IV.

Analysis of the fluid inside at the end of the experiment showed the presence of Leucine and Tyrosine, many microorganisms and Sarcinæ and a trace of alcohol. Both the Biuret and Xanthoproteic reactions were only slightly marked. There was only a trace of Chlorine inside and none dis-

-coverable outside. (charts III & IV show the course of the experiments.



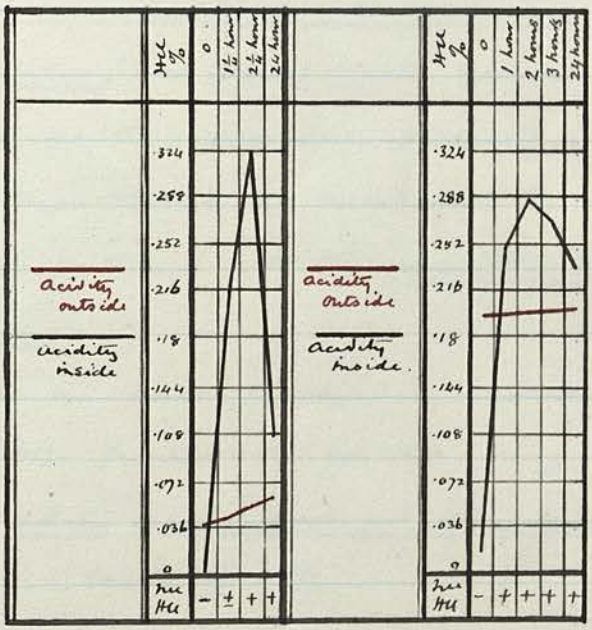
(chart III

(chart IV

Experiment 7. I again performed a similar experiment, but in this the course of the acidity inside the membrane was more striking, the contents being Bouillon with gelatine added as before, but much more concentrated. It will be noted that in an hour and a quarter the acidity rose from neutrality or slight alkalinity to more than five times the acidity outside and in two hours and a quarter to nearly seven times as much. In 24 hours

the acidity had fallen again inside to a little less than ~~half~~ twice that outside. See Chart V

Experiment 8. The former experiment repeated with .198 % HCl sol. outside, the acidity inside rises here only to .288 %, but the fluid used was more dilute. See Chart VI



(Chart V.

(Chart VI.

From these experiments I clearly saw that there was some other power than pure osmosis at work and I set myself the task of endeavouring to find out what influence these facts have on the processes of Gastric Digestion. I will now draw these conclusions which seem to me to be warranted by the experiments and facts stated above.

1. That albuminoid bodies in solution have a power of attracting and probably combining with Hydrochloric acid.

2. That this acid so combined, even if although greater in quantity and strength, does not prevent more pepsin HCl from dialysing through.

3. That this combined acid, if placed in a dialyser with water round (Chart I) does not dialyse through so completely, nor so quickly (Chart II) as the uncombined acid.

4. HCl has no power of combining with the carbohydrates, at least with glucose. (Exper. 4)

5. That as the experiments proceed and the albuminoids pass through the membrane the combined acidity passes through with them and the total acidity inside falls.

6. If in one case the acidity outside be less and in another greater, the contents being much the same, the acidity inside does not vary in proportion. (cf. p. 106). Charts V & VI.

7. That if the contents vary in concentration, the acidity varies directly with it. (Charts V & VI.)

8. That $NaCO_3$ does not seem to combine with albuminoids, or, if it does do so, only to a very small extent. This point needs further investigation. ((Charts III & IV)

So far then, these experiments were done without the addition of pepsine. I now performed some similar experiments in which that ferment was used, but as several of them were carried out more especially with reference to the life of

Microorganisms under the influence of gastric digestion, I need only reproduce two of the charts and experiments here, a more detailed account will be found below. (p358)

Experiments 9, 10, 11, 12. Nos 1. 2. 3. 4 in Chart VII

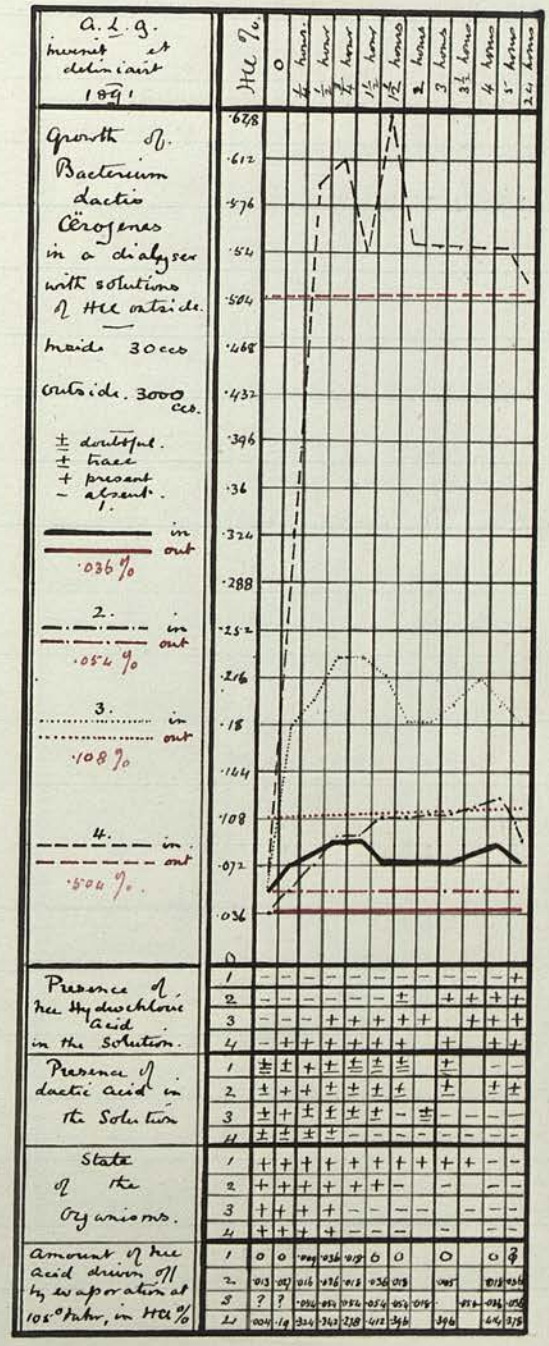
In this series the solutions placed inside the dialyser tubes were of the same character throughout but in No 9 (1.) the solution was concentrated in the other three more dilute. The substances used were beef-broth, milk, and fibrin in water. The acidity outside was obtained by solutions of HCl of different strengths 1. ·036%, 2. ·054%, 3. ·108% 4 ·504%. The course of the acidities as depicted on the chart explains itself. The horizontal lines represent the acidity outside, the curved that inside. The portion of the chart devoted to the presence or absence of free acid is also easily explained, – standing for absence, + for presence.

The amount of free acid driven off by evaporation is also given and, to avoid having too many lines on the chart, is noted in figures.

That part of the chart referring to the growth of the organism examined in this series of experiments will be discussed later.

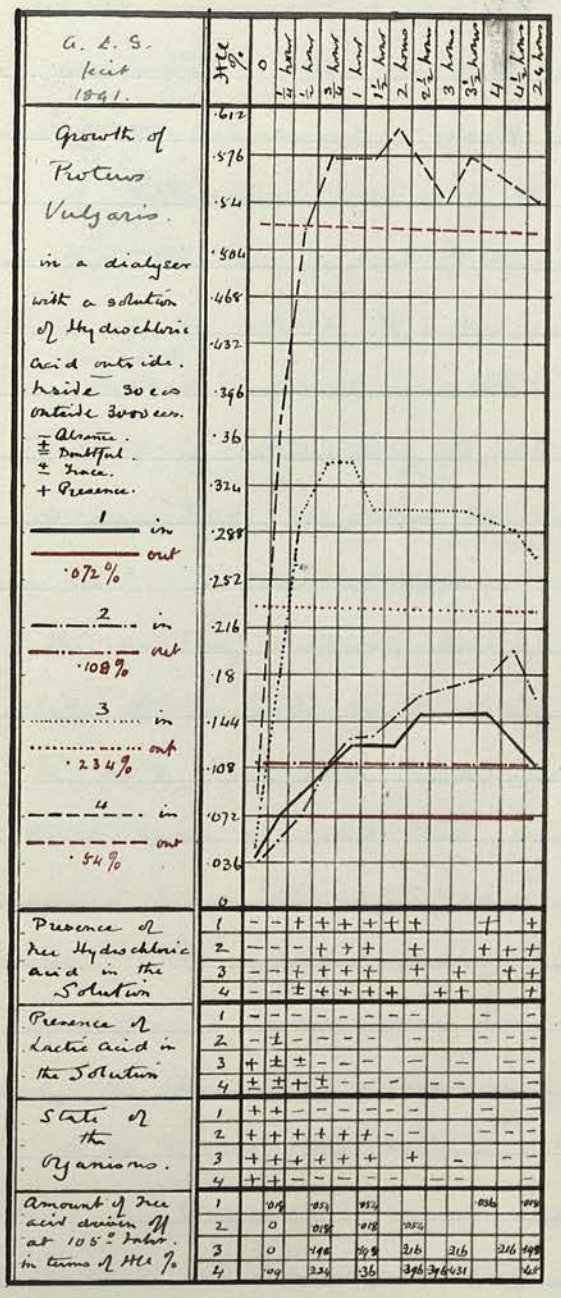
The beakers with the dialysing tubes and solutions were kept at 100° Fahr. The apparatus with the HCl solution was warmed up to that temperature before the contents of the tubes were poured in, so that the commencement of digestion could be accurately timed.

(Chart VII.



Experiments 13, 14, 15 and 16, were performed on exactly the same lines and are depicted on (chart VIII, the bacteriological side is discussed below (p. 370).

Chart VIII



These two charts give a very good idea of the course of the acidity in artificial gastric digestion occurring in dialysers. It will be noted that in those cases in which the acidity outside was weak the acid maximum inside occurred late—at the fourth

or fifth hours, while if the acidity outside was stronger the maximum inside was reached from the first to the second hour, at latest. The acidity always fell towards the end of the experiment; inside from the dialysis through of the peptones formed by the digestive process; outside from the use of part of the acid inside, but the evaporation of the whole to a few ccms less kept the acidity per cent. outside almost constant.

In Chart VII it is interesting to note the time of appearance of free HCl, as shown by Günzburg reagent, during No 1, it does not appear until after the fifth hour, the acidity outside being very weak, only .036%, while the contents in the dialyser were concentrated. In No 2 free HCl appeared at the second hour, a trace being recorded then, while in No 3 only $\frac{3}{4}$ hour elapsed before its appearance and in No 4 less than $\frac{1}{4}$ hour. The appearances of free HCl in Chart VIII is different because in No 1, where it appears early the fluid within was very dilute as also in No 2, in No 3 the fluid was a little more concentrated, while in No 4 the time of appearance of the free HCl is put on from before the $\frac{1}{4}$, as the last chart, to before the $\frac{1}{2}$ hour, only a trace occurring at that time.

In Experiments 9, 10, 11, & 12 the presence or absence of Lactic acid does not interest us here as the organism incidentally tested gives rise to that acid from its fermentative action. (cf p 333)

But in Chart VIII a trace of lactic acid is noted at the beginning of the last three of the experiments. In no. 1. the fluid was so dilute that the trace of lactic, if present, could not be accurately determined to be there.

The total amount of acid driven off by evaporation at 105° Fahr., after 24 hours, no free HCl being then in the residue, increases gradually in each case to about the 3rd or 4th hours and then sinks a little, it will be noted however that the total free acidity inside very rarely equals and, in these instances at least, never exceeds the total free Hydrochloric acid outside.

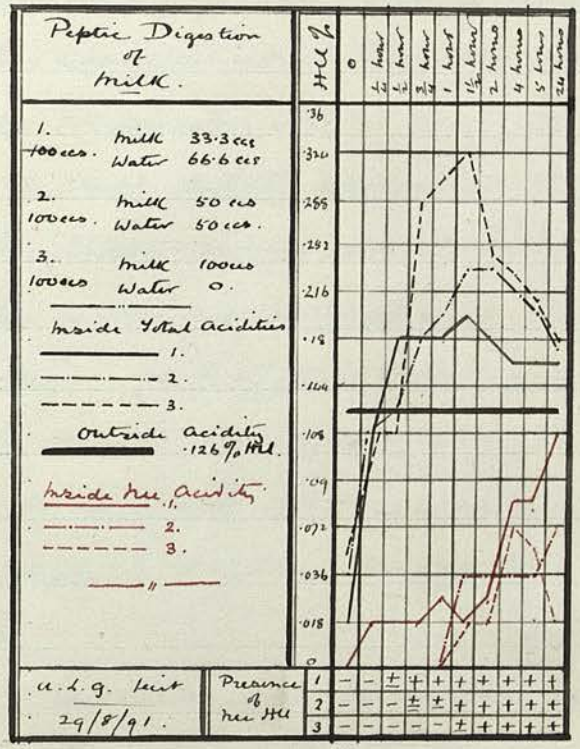
Wishing to ascertain the exact influence of the presence of Proteid inside on the acid curves I performed the following experiments,

Experiments 17, 18 & 19.

Using a dialyser as before I placed 100 ccs of a mixture of milk and water, $\frac{1}{3}$rd of milk and $\frac{2}{3}$rds of distilled water in the tube and poured round it 3000 ccs of a .126% solution of HCl of a temperature of 100° Fahr. The whole was kept at 102° Fahr., a small quantity of Pepsina Porci being added to the fluid inside.

I repeated this experiment in exactly the same way with half milk and half water, and again with pure milk inside the tube. The acidity was estimated every $\frac{1}{4}$ hour till the first hour, then every $\frac{1}{2}$ to the 2nd hour, at the 4th 5th & 24th hours.

Chart IX



It is obvious from these three experiments that the course of the acidity inside varies with the contents, not only because of the law of osmosis that a fluid of greater density attracts more of a lighter fluid, for if that only occurred here the percentage of acid present inside would not rise above that outside. Another point seen is the rapidity with which the HCl dialyses through, and that it begins to do so at once, a point in which I believe it resembles nature and which I hope to prove below. The period at which free HCl makes its appearance is also very instructive, being proportionately later the stronger the milk solution. In numbers one and three there was a small quantity of free acid not HCl driven off at first. The Chlorine was estimated in No 1.

in addition to the acidity, but as the Chlorine Curves follow closely those representing the course of the acidities I have not added them to the chart, which is sufficiently complicated without them. Another point is that in the more dilute specimens the free acid at the end of the Experiment is considerably greater in quantity than in the more concentrated. The fall in the free acid curve in No 3 of this series is unusual and is either due to an error in observation at the fourth hour, or to loss in specific gravity of the fluid inside from dialysis of peptones, leading to a diminished inflow of HCl.

If one considers, with Hoster, that milk contains when fresh, 4% of proteid, or with König 3·4% the proportions of acid to proteids were as follows at the 1½ hour when the acidities were highest.

	Acid as HCl	% Hoster	% König
1	·198 Gr.	14·8	17·5
2	·234 Gr.	11·7	13·7
3	·324 Gr.	8·1	9·5

But these numbers can only be approximate for by an hour and a half the 100 ccs inside had become several ccs larger in quantity. Nos 2 & 3 being more concentrated originally, attracted a greater quantity of water from outside, while less dialyzed through in No. 1. And again by this time some of the proteid had become peptone, part of which had dialyzed out, and necessarily affected the above

proportions. However that may be, there is sufficient evidence from these experiments to prove that the larger the amount of HCl present as compared with the amount of proteid, the more of it combines. And, as HCl combines with proteids before digesting them, the amount of combined acidity serves as a guide in estimating the digestive power of the gastric juice, artificial or natural.

Experiment 20. In this experiment I simulated nature as far as I was able, excepting that I did not keep the tubes in the Dialyzer moving. I performed it to get an idea of the digestion of meat alone in an artificial digestion apparatus, and to enable me to compare it with similar experiments on the digestive processes in man.

The apparatus used was as before, except that, as the meat to be digested was a large one, six parchment tubes were used and three beakers, two tubes in each beaker, surrounded by 100 cccs of HCl solution. As the experiment proceeded, at each time the contents were to be analyzed, a tube was removed and its contents tested. One tube was taken out of each beaker successively, and then the remaining one from each. The acidity of the fluid in the beakers and round the tubes was tested on each of these occasions.

The material to be digested was prepared as follows, a large quantity of fibrin, sheep's

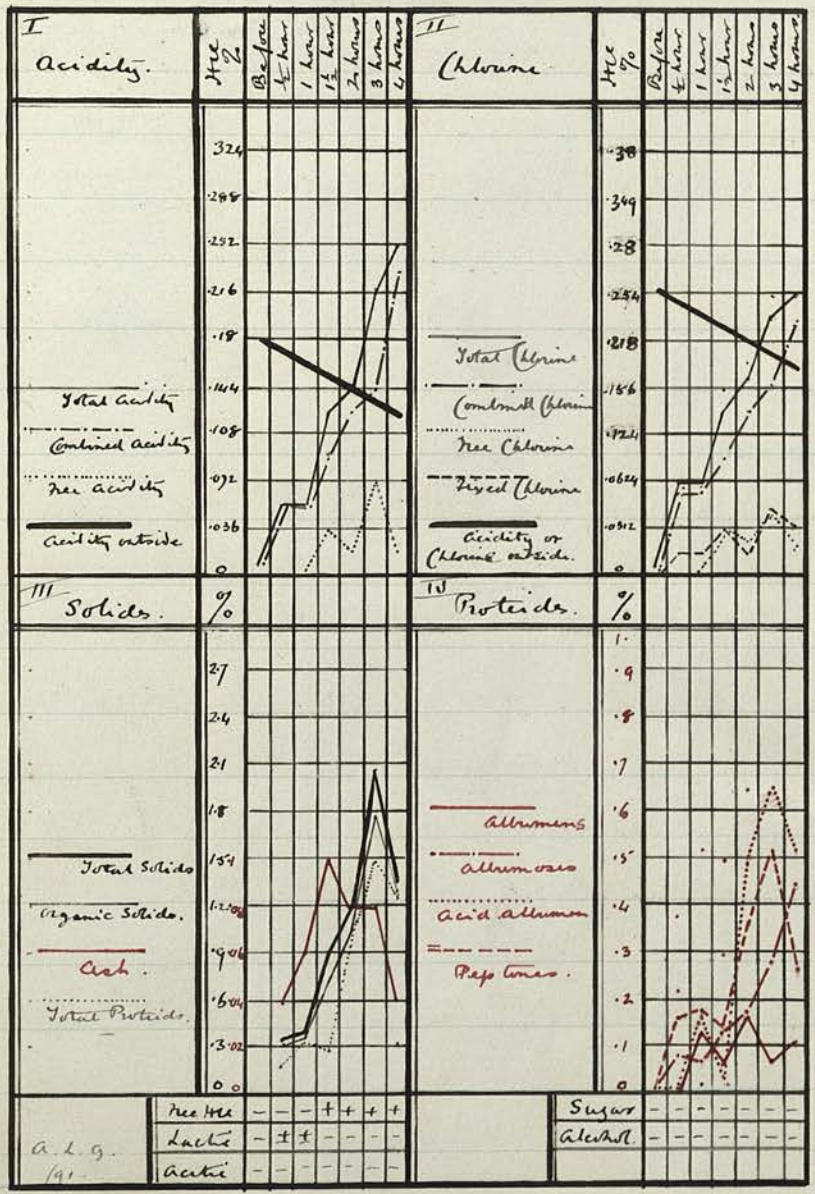
heart, chopped into very small pieces and some pieces of white of egg, boiled and cut into small cubes, was placed in a flask with 250 ccs of water, boiled and cooled. When cool 20 ccs of saliva were added to it, and the mixture kept at 40° C for one hour. The water was then strained off and the solids divided into 6 different parts of the same weight, - approximately, - each, and the water which they had been boiled in was added to each part up to the 70 cc. mark. Each tube then was filled with the 70 ccms. of material and placed in the Beetles.

A small quantity was filtered and tested, it had an acidity of .004 % HCl, with no free acids in it, and contained a trace of Chlorine.

The solution outside was made up of a .18 % sol. of HCl in water, Chlorine .1872 %, and as usual was warmed up to the temperature of the body before putting the tubes in.

It will be seen from Chart X, which is only an amplification of the previous ones, that the acidity rises quickly, and at the 2nd hour exceeds that outside, but that it does not rise so quickly as in the case of the milk, the proteids not being so finely divided and therefore, more difficult to digest. Free HCl does not appear until 1½ hours after digestion has started, and never rises above .04 %, the free acidity rising in the third hour to .072 %.

Chart X.



The material used inside being difficult to digest and, the experiment only lasting 4 hours, the acidity was highest at the fourth hour, though probably it would have fallen by the next hour, if the experiment had been continued, as the total Solids had begun to decrease. The right half of the chart is devoted to, above, the Chlorine, below the Various Proteids.

The Chlorine curves follows very closely the acid curves, the free HCl being only slightly less than the total free acid, that is to say that there is only a trace of organic acid present. The fixed chlorine rises from the beginning and reaches .042%, it may either come from the chlorides in the meat or from the action of the HCl on the other salts.

On turning to the table of the total solids, it will be seen that they are most at the third hour in the filtered contents, and then fall considerably, from 2.% to 1.4% at the fourth hour. On the other hand the inorganic salts are most at the hour and a half, though containing much chlorine at the third. They rise rapidly at the beginning, but fall nearly as quickly at the end. Subtracting the ash from the total solids, the amount of the organic solids is obtained, it naturally corresponds very closely in amount to that of the total solids. The dotted black line drawn in this division indicates the total amount of proteids; it follows very closely the total organic solids. I have entered the total proteids in this division because the division devoted to the individual proteids is not large enough, and also for the purposes of comparison.

The fall in the amount of total proteids recovered at the first hour cannot be satisfactorily accounted for, but it is slight and may be an error in working.

The fourth table, or the separation of the Proteids into their four chief divisions, shows a fairly constant

quantity of Serum albumen and Globulin, a greatly increasing quantity of acid albumen, in which the artificial digestion differs considerably from nature, while the amounts of albumose and peptone present rise more gradually and regularly.

On comparing the total acidity curve, or better the combined acidity curve with that of the total Proteids it will be noted that they have a considerable similarity until after the third hour, when the proteid line falls a little the acid line still rising. This I attribute to the increased amount of Peptones and albumoses, which form the most of the Proteids present in the fourth hour, as I believe that these proteids take up more HCl than the albumens that go before them in the Proteid Series (cf p. 241).

It is very doubtful if there really was ably Lactic acid present during this experiment, the reaction with Uffelmann's reagent was very doubtful and I am inclined to think with Rothschild[179] that with purely a flesh diet the amount of Lactic acid formed is very small, although, if there be carbohydrates along with the Proteid, Lactic acid fermentation set up by them may possibly influence the Proteid esp. if it be in the form of Myosin, and give rise to more Sarcolactic acid than the Proteid by itself could have done.

There was no Sugar, Alcohol or Acetic acid discoverable in the contents at any time.

Von Jaksch [15] recommends that, in testing the contents of the stomach, the acidity etc should be calculated from the unfiltered as well as the filtered fluid and it may be readily conceived that the unfiltered contents may now be more acid, now less so than the filtered as the undissolved Proteid is greater than the dissolved, or as the undissolved material contains much Carbohydrate.

I therefore in this experiment and in several of those to follow tested the fluid under both conditions. The previous charts and remarks refer to the filtered contents. I did not consider it advisable in this case, not knowing the exact amount of solid material I had to deal with from the commencement, to estimate the Total unfiltered Solids, Ash etc, nor could I calculate out the Proteids with any accuracy. The acidities were in nearly every case either equal to or higher than those in the filtered half, the Chlorine curves, of course, taking much the same direction. For instance, the Total Acidity at the six periods of the experiment in the filtered were ·054 ·054 ·126 ·144 ·216 ·252 In the unfiltered, ·072 ·072 ·126 ·162 ·216 ·27

While the combined acidity kept much the same proportion; filtered. ·054 ·054 ·126 ·144 ·144 ·234

unfiltered, ·072 ·072 ·126 ·144 ·162 ·144

falling below the filtered however in the last two hours due probably to much of the Proteid being dis-

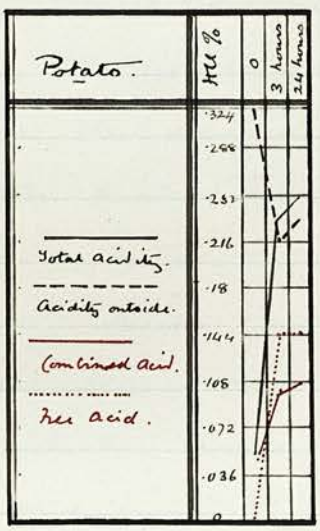
solved & the indigestible matter left.

The free acidity is almost the same, a slight increase here, a slight decrease there.

Exper. 21. Noting then the result of digestion of almost pure Proteid, I next performed a very similar experiment on an almost pure Carbohydrate. I used Potatoes for this, boiling a considerable quantity in an equal quantity of water, after having mashed them. I made in fact a thick Potato soup. On testing this I found that it had an acidity of ·054 % HCl and contained ·0468 % Chlorine.

Inside the Dialyser tube I placed 80 ccs of this mixture, and outside it 180 ccs of an HCl solution ·324 %, Chlorine ·324 %. I added a small quantity of Pepsine to the Potato.

(Chart XI



From this chart it will be seen that though the acidity rapidly increases in the three hours that inside goes very little above that outside, and that at the end of 24 hours the proportion is much the same. The combined acidity line is very striking, comparing it with some that have gone before; it only rises to .108 %, the free acid on the other hand rises more rapidly to .144 % and remains there and is therefore in greater quantity than the combined unlike the previous experiments.

The fluid inside after the experiment was finished gave no Biuret reaction, but reduced Fehling's solution, gave the tests for peptone and coloured a Iodine and Iodide of Potash solution violet, showing the presence of Starch and erythrodextrine.

Outside the fluid reduced Fehling, gave the tests for peptone, Biuret reaction doubtful. no Starch.

On examining the proportion of Chlorine inside and out both at the third hour and after 24 hours it was only slightly greater inside than outside.

At the third hour Inside .234 % Outside .1716 %

at the 24th hour Inside .312 % Outside .2796 %

The apparent discrepancy in the quantity of Chlorine altogether is due to the evaporation of the fluids, the total at the end being 81 ccs inside, 165 ccs out. The total amount of Chlorine at the beginning being .686944 gr at the end .717 gr. an error of .03 gr in the working, an error which I find almost

constantly in working out (chlorine results. This is due probably to the addition of a drop or two too much silver solution to make sure that the change of colour is permanent. This is especially the case when the fluid has contained free HCl, for the colour produced by that acid on the proteids when the fluid is dried, obscures the end of the reaction. This is also a source of some uncertainty as to the end of the reaction in testing the acidity with phenolphthalein. In both cases considerable dilution with distilled water is advisable, and, in estimating the acidity, a larger quantity of phenol phthalein than usual.

For this reason again no colour which changes its shade on transition from acid to alkaline can be used with any accuracy at all. One which is colourless with the one and coloured with the other is requisite.

<u>To sum up the experiments from 9 to 21.</u>

1. The deductions from the previous set of experiments (c/f p.) are, I believe, confirmed by this new series, but the <u>presence of pepsine increases the acidity</u> with which Hydrochloric acid combines with Proteid bodies.

2. Experiments 17, 18 and 19 prove conclusively that the <u>increase of acidity varies directly with the density of the contents</u>, but, considering Exper-

-ment 21 on Potato, it is seen that in these experiments it is not the density of the whole bulk of the contents, but the proportion of Proteids in them; in the series of digestions of Milk, for instance, the proportion of Proteid is comparatively high, the acid curve is high, in the Potato soups the proportion of Proteids is extremely small — König says Potato contains 2% of Albumenoids, — the combined acidity is low. While in Experiment 20 on substances almost purely proteid, the acidity was still rising when the experiment had to be stopped.

2. It is possible to ascertain roughly the proportion of acid which is allied to Proteids. For instance in the milk series it varies from 8·1% to 17·5% and considering Potato to have 2% of Proteids the amount combined is between 7 and 8% at the third hour, but is probably higher as the quantity of Proteid which had dialysed was not noted. While in the digestion of Proteids, Exper. 20, if the proportions are worked out, excluding the figures at 1 hour which are manifestly absurd giving a figure of 32%, the percentages of acid to Proteid vary from 10% to 18%. × (cf. p 241)

3. It is seen from all these experiments that Hell begins to dialyse through at once; it has a remarkable power of rapid dialysis, 34 times greater that that of Common Salt according to Graham.

4. Still more is evident from these observations the truth of the second deduction on page 108, that

the presence of combined HCl in a solution does not prevent the further dialysis of free HCl through, but it is most markedly brought out in Experiment 21 (chart XI that even with a small quantity of combined HCl present the free HCl inside does not reach the height of that outside. That in fact the law cuts both ways 1. That no amount of combined acidity inside, if all the Proteids be saturated, will prevent free HCl dialysing through from outside

2. That the presence of even a small quantity of combined acidity inside, prevents free HCl dialysing through in the same proportion and up to the same amount, as the free HCl out; that in fact, though the Combined plus the free inside are always greater than the free outside, the amount of the free inside — if combined be present as well — is always less that the amount of it out.

These proportions vary of course as peptones + their acid make their way outside, but as in all the experiments the amount of acid solution outside was in great excess purposely, so the presence of the peptone formed did not materially affect the total quantity of free acid. The solution outside in fact resembling the proportionately inexhaustible reservoir of HCl in the healthy body.

5. The combined acidity represents the amount of Digestive work going on. This is simply a corollary of No 2.

6. The Total Solids in an artificial digestion carried on in a dialyser, rise rapidly in the filtered contents until the 2nd or 3rd hour and then fall, the inorganic part however falls sooner, reaching its maximum at the 1st hour or at 1½ hour.

7. The Proteids in solution increase up to the third hour, if in big pieces at first, up to the 2nd if more finely divided, and then fall.

8. In unfiltered specimens, with principally a Proteid composition, the acidity is greater than in filtered specimens, but before the end of digestion may fall below it.

6. The course of the Acidity and its relations to the contents of the stomach in man.

I now performed some similar experiments on the Gastric digestion in man and to enable me to do this I was luckily enough to find a patient, suffering from a slightly dilated stomach but whose chief affection was dyspepsia of a neurotic type. She was in the habit of washing out his stomach twice a day as a rule, or rather I should say, of siphoning off the contents of his stomach by means of a stomach tube. He had suffered from this affection for many years and had been given every drug that could be thought of in connection with his ailment. Of a very nervous temperament he

used to imagine that the state of his stomach rose from all sorts of absurd causes, and, being somewhat of an empiric himself, he endeavoured to treat it apart from the suggestions of his medical man. A white pasty complexion, thin habit of body, quick restless movements and a constant desire and pleasure in talking of his illness in all its aspects, a readiness to impute any exacerbation to trifling causes, as for instance any peculiar smell perceived as he passed along the street, all pointed to the nature of his malady.

The local symptoms of which he complained were, pain in the stomach relieved by eating and coming on three or four hours after, relieved by doses of Bicarbonate of Soda or by siphoning off the contents, one of these proceedings being invariable after every meal; as a rule the pain was of a gnawing character, but, especially after partaking of vegetables, now and then became burning. The burning pain was relieved for a short time by the Soda and was evidently due to organic fermentations. He complained constantly of his stomach being too acid and put down all his discomfort + trouble to hyperacidity but analysis of the contents failed to reveal any especial acidity. He had slight tenderness over the Dorsal spines behind. His bowels were obstinate and required frequent solicitation, but there was no want of biliary pigment in the stools

or excess of pigment in the urine.

He was in fact a case in which the Stomach nerves were hypersensitive to the irritation caused by acids, in which digestion went on well until the acidity had increased to that point at which the irritation commenced and in which, after that point had been reached, his discomfort increased so much that he either had to drown the acidity, to the detriment of his digestive powers, with overdoses of Soda, or had to remove most of his food with the stomach tube before he could absorb sufficient nourishment from it to help his nervous system or put flesh on his bones.

The addition of the Soda was probably the least harmful for the result could be passed on to the Duodenum for further digestion there, but frequently, the action of the Soda being but temporary, the pain would return and with it the withdrawal of the Stomach contents with the tube.

Arsenic, Strychnia, Bismuth, Iron, every thing was tried, the only drug of benefit was found to be Opium in small doses, given usually in the form of Dovers powder, and this acted presumably by deadening the nerve terminations in the walls of the stomach.

The Patient, T. B. taking an interest in the acidity of his stomach gladly consented to place that again at my disposal for its examination. He had moreover become such an adept

in passing the stomach tube, that, without the help of Cocaine to dull the pharyngeal reflex but with the aid of a small quantity of glycerine to moisten the outside of the tube, he could pass it into the stomach, siphon off the contents into a small receptacle and remove the tube without allowing a drop of the fluid to enter his mouth or a drop of saliva to fall into the dish. So that the proceedings were conducted with a minimum of discomfort and a maximum of accuracy.

In all I carried through four experiments on this patient

1. On gastric digestion after a meal of bread and butter, white fish and coffee.
2. On gastric digestion after a meal of mince, bread and butter and a cup of water.
3. After a breakfast consisting solely of Porridge, no milk or water being taken.
4. After a meal of ripe greengages.

During the first experiment at the third hour the supply failed and the experiment had to be stopped, but two days after he took a similar breakfast and the analyses were begun at the second hour, the results being incorporated with those of the previous seance.

All the experiments were done in the forenoon after breakfast, except the last, in which the first

was taken for lunch some 4½ or 5 hours after breakfast when the stomach was presumably empty.

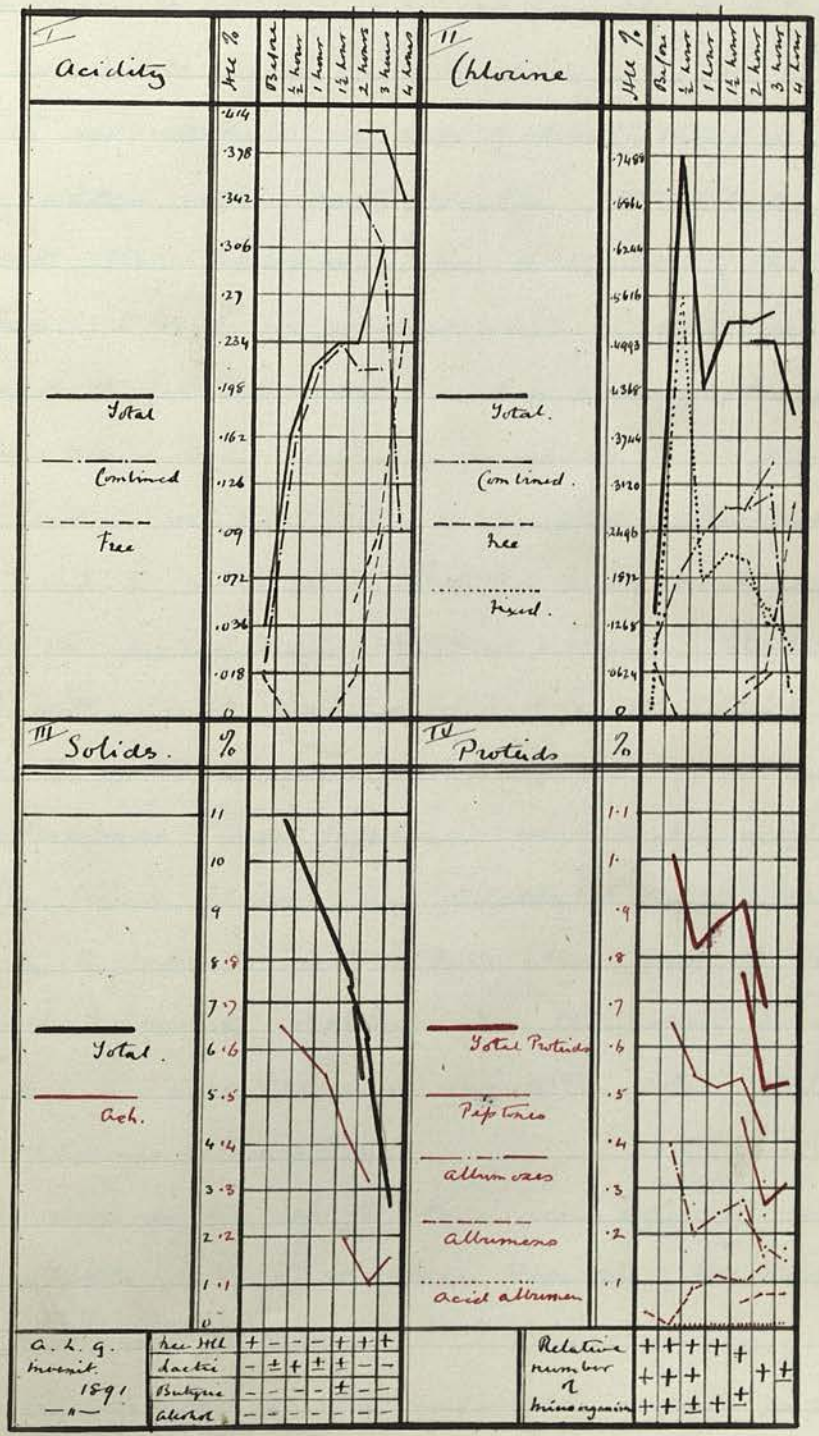
Experiment 22.

Half an hour before breakfast the patient experimented on passed the stomach tube and drew off a small quantity of fluid, having however to pour in about an ounce of water before the siphon action would work. The fluid obtained was colourless, slightly opaque and contained a few flakes of mucus. There was only sufficient to estimate the acidity and Chlorine, the Total Solids, ash and Proteids had to be missed out. Breakfast was now taken, consisting of coffee, bread and butter and some white fish. The contents of the stomach were then withdrawn at half an hour, one hour, an hour and a half, two, three and four hours after. From the half hour up to the three hours, the results were from one day, but, as I stated above, there was not sufficient fluid to enable the experiment to be proceeded with at once, so, after a similar meal two days after the fluid was again analysed at the second, third and fourth hours.

The results of the analyses are depicted on the following chart, the double line at the second & third hours representing the two different sets of analysis, and it will be seen that they are very similar, the increased acidity of the second being

probably due to the fact that no food had been previously withdrawn.

Chart XII.



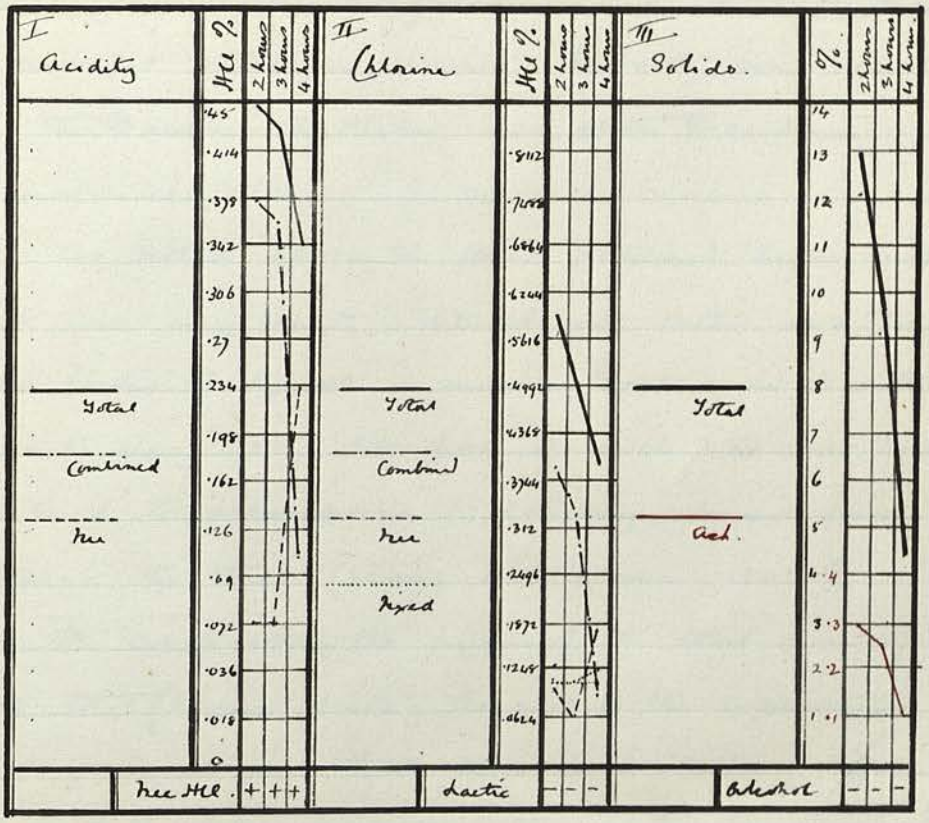
Each time the contents were siphoned off the following procedure was adopted, — about 30 ccs were as a rule procured, — 20 ccs of this was filtered and either 5 ccs or if only a small quantity of the fluid was available 2 ccs were used to estimate the total acidity and chlorine, a drop of dilute nitric acid being added after neutralisation with the Soda to prevent the phosphates from precipitating the Silver solution. 2 or 5 ccs were set aside to evaporate. 10 ccs of the filtrate was placed in a weighed capsule, — sometimes only 5 ccs were available, — dried at 110° Cent. weighed, then incinerated. The fluid left was used to estimate the Proteids, being neutralised just to precipitate the acid albumen, the filtrate boiled with acetic acid & filtered, the filtrate saturated with Ammonium Sulphate to separate the albumoses from and peptones as detailed on p.

The fixed Chlorine was calculated from the ash left in the capsule after incineration and the free & combined acidity & chlorine from the portion set aside to evaporate in a similar way to the Total Acidity and Chlorine estimation.

A drop or two of the fluid was used to test for free HCl with Phloroglucin Vanillin, for Lactic acid and for alcohol.

The analysis of the unfiltered contents was only carried out in the second half of the experiment and the result is embodied in Chart XIII.

Chart XIII.



At each period also, before the fluid was tested at all, gelatine tube plates (cf p. 94) were inoculated from it by means of sterilised platinum needles, unluckily however I could only manage to overcome a qualitative estimation of the organisms grown, the amount of time taken in working out the results of the rest of the experiment preventing my paying sufficient attention to the plates to enable me to separate out and identify pure growths of the organisms present. The number fell from innumerable colonies on the first plate to a few, 12 or 20 on the last, some were yeasts, and some formed white non-liquefying colonies on

the gelatine, but the majority consisted of germs which liquefied the gelatine and which produced a powerful putrefying odour. Probably some variety of the Bacillus Subtilis and of the Bacillus liquefaciens Elsi.

1. Filtered. As noted above the fluid obtained before breakfast was very scanty, diluted with water and had some flakes of lymph or mucus floating in it, its acidity was .036% HCl half of which was free, half combined to albumenoids. With only a trace of fixed Chlorine the total Chlorine was above .1248%.

On constructing the curves of the total acidity and total Chlorine during the rest of the experiment, it is seen at once that there is a striking difference, the acidity rises quickly to .162% then increases slowly during the next hour and a half up to .234%, when again it takes a jump upwards to .306% at the third hour, in the second part of the experiment it shows a fall between the third and fourth hours; the total Chlorine, on the other hand, jumps up in half an hour to .7488% and then falls in the next half hour to .4368%; a slight rise to .5193% at the third hour and a fall at the fourth completes the curve.

Before explaining the apparent discrepancy, the curves of the combined acidity and chlorine should be studied. It will be seen at once that they are almost identical. The acidity not driven off by heat rises with the total acidity to .234% at the hour and a

half then falls slightly, the Chlorine combined to albumenoids rises in a similar manner to .26%, then rises slightly, while the acidity in the second part of the experiment falls rapidly from .342% to .09% the combined Chlorine in the same part falling from .28% to .057%.

The acidity up to an hour and a half was all combined, and a small piece of fibrin placed in a few ccs of the fluid taken at that hour did not show any traces of digestion after 24 hours at 40°C. At the second hour however, free HCl, only .018% ~~indeed~~, made its appearance and the combined acidity fell a little below the total. A small piece of fibrin, which had been previously boiled, placed in a few ccs from this hour's fluid was completed digested by 24 hours. At this hour also, the patient began to feel uneasy. Rising to .09% at the third hour, during the fourth the free acid curve reaches .252% and by this time the patient was suffering from considerable pain. The free chlorine as HCl. follows exactly the steps of the free acid, but the curve of the fixed Chlorine is very different, rising, as it does, in half an hour from almost zero to .5616% then falling to .1672% and, after a temporary and slight recovery, further to .09%.

It is now apparent that the reason of the irregular Chlorine curve is due to inorganic chlorides, in fact to the salt swallowed with the food, most of which are quickly absorbed and doubtless secreted again as

free Chlorine, that is to say as HCl.

The acidity and Chlorine then fall between the third and the fourth hours, the total amounts slightly, the combined largely, while the free increases proportionately.

Turning now to the Total Solids it is seen that they fall progressively from 10·9 % to 2·6 %. the fall becoming more rapid during the later hours. and corresponding to the fall in the combined acid and chlorine. The inorganic constituents also fall in much the same ratio from ·65 % to ·32 and ·1 %.

The total proteids are much less in amount than the Solids, the largest quantity 1·1 % is at the half hour, largely composed of peptones and albumoses, then falling to ·82 % they rise till at the second hour they reach ·9 % then a sudden fall.

Of the individual proteids the albumen will be seen to rise gradually to the finish, the amounts present being very small, the acid albumin remains merely a trace, a cloudiness on neutralisation and unweighable, throughout the experiment. The peptones and albumoses beginning high, fall at the half hour, rise till the second and then diminish again.

Lactic acid was present from the half hour until the second, but only in decided quantity at the hour. At the second hour there was a trace of Butyric acid.

No alcohol could be discovered at any time during the experiment.

2. Unfiltered. (hart XIII contrasts very considerably with the last half of (hart XII.

The total acidity and (hlorine at first much above the former totals, ·45 — ·386 %, ·5916 — ·4992 %, become equal to them at the fourth hour.

The combined acidity and (hlorine also above those noted before, remain slightly above them at the end of the experiment, ·108 — ·09 %, ·0936 — ·0312 %.

The free acidity and (hlorine is on the whole slightly below that in the filtered specimens, the acidity free at the end being ·234 : ·252 %, the (hlorine ·1872 : ·2808 %.

The Total Solids, at first as 13% to 7·09 %, at the third hour 9·8 % to 6·2 %, and finally as 4·3 % to 2·7 %, keeps a constant relationship with the three in the last table, the ash also being slightly in excess. The organic solids, that is the Total Solids minus the ash, and also with the combined chlorine subtracted are, at the three different hours;

Unfiltered; 12·244 % 9·175 % 4·206 %.

Filtered; 6·89 % 5·65 % 2·442 %.

Hydrochloric acid in the free state could be detected by Günzburg's reagent on each occasion, Lactic acid was not detectable in either, nor was there any alcohol.

—

Experiment 23.

This experiment was undertaken both to corroborate and to extend the last one.

The fluid in the stomach before breakfast could not be obtained in sufficient quantity to test.

Breakfast consisted of mince, made with a considerable quantity of water, bread and butter and a breakfast cupful of water. As on the previous occasion food was taken until the natural cravings for it were appeased.

Observations were made at ½, 1, 1½, 2, 3 and 4 hours. The procedure adopted was the same as last, but no tube plates were made. As there was a little more fluid available, six new investigations were added. First the total Proteids were directly calculated, (not from addition of the various forms as before,) 5ccs of the fluid being evaporated to small bulk, the proteids contained in it precipitated with absolute alcohol and weighed; the amounts of the individual proteids found after could thus be used to check the result. Secondly the albumoses were separated into their three varieties and weighed, this was done by means of salt and dialysis (cf p. 68) Thirdly the amount of Sugar present was quantitatively determined. Fourthly the presence of starch or of Erythrodextrin was ascertained by means of Iodine and Iodide of Potassium. Fifthly, mucin was qualitatively determined. While lastly the digestive power of the different samples was

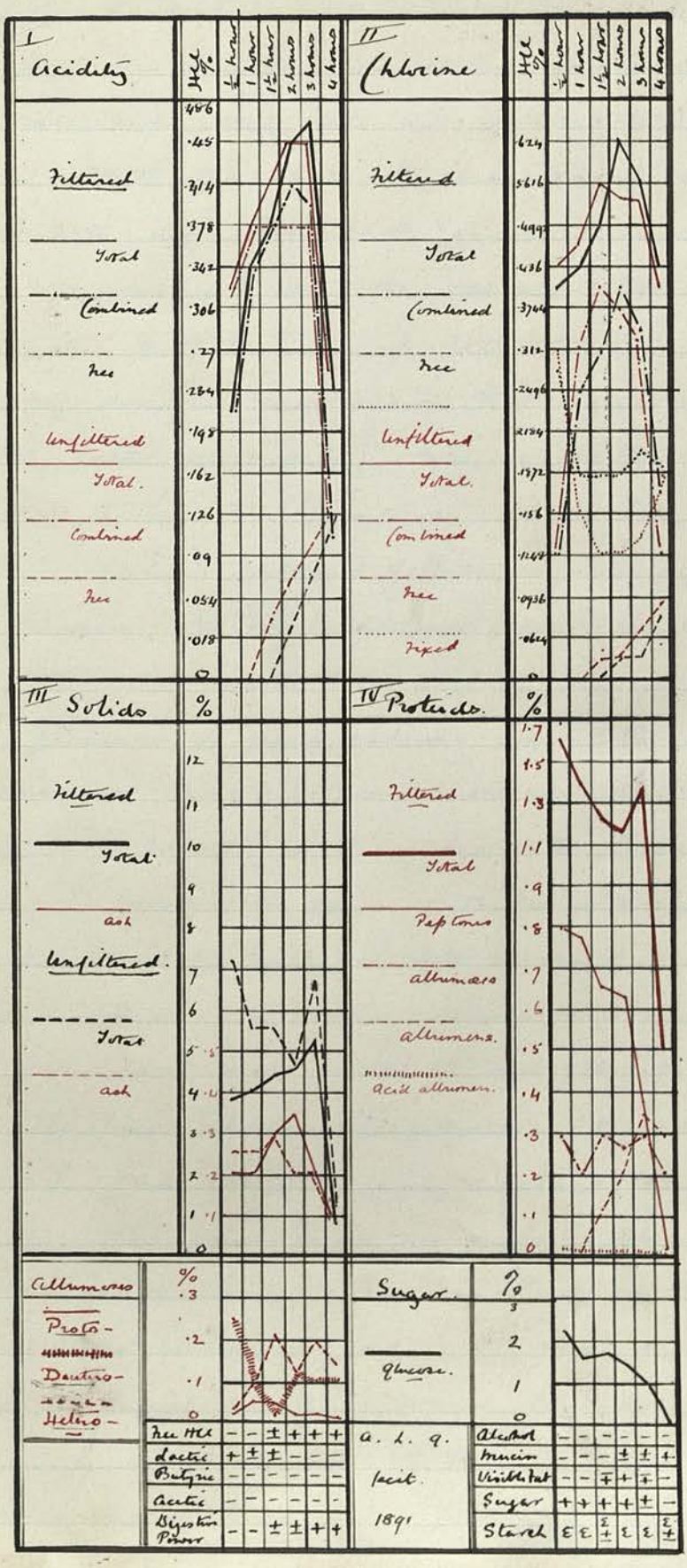
gauged by placing small pieces of boiled fibrin in a few cc.'s and placing it at 40° Cent. in an incubator.

The fluid obtained at the half hour had a slight gastric smell, but there were little signs of the head and no fat to be seen. At the second hour fat droplets could be seen on the surface, and also at the third hour, when the fluid was very thick. At the fourth hour very little fluid could be got and that obtained was largely mucus.

On reference to the Chart on the following page, which is similar in construction to the previous ones, the filtered and unfiltered results being, however, placed in the same divisions, the unfiltered results in red in the Acid and Chlorine divisions, in broken lines in the Total Solid part, it will be at once noted that the curves in both the acidity and chlorine sections closely resemble in form those of the preceding experiment, except that the amount of salt taken with the food was temporarily diminished and consequently the Chlorine total at the half hour is less prominent.

Filtered: The Total acidity rises abruptly till the second hour, then after a slight rise at the third, rapidly falls; the combined acidity rises until the 2nd hour when it reaches .414 %. then, falling slightly at the 3rd hour, reaches the low figure of .108 % at the end of the experiment; that is to say that, at the hour between 2 and 3, the absorption of peptones was proceeding at such a rate that the acid com-

Chart XIV


I Acidity
HCl %
½ hour
1 hour
1½ hour
2 hours
3 hours
4 hours
·486
·465
·714
·378
·342
·306
·27
·234
·198
·162
·126
·09
·054
·018
0
Filtered
Total
Combined
Free
Unfiltered
Total.
Combined
Free
II Chlorine
HCl %
·624
·561
·499
·436
·3744
·312
·2496
·2184
·1872
·156
·1248
·0936
·0624
·0312
0
Filtered
Total
Combined
Free
Unfiltered
Total.
Combined
Free
Fixed
III Solids
%
12
11
10
9
8
7
6
5·5
4·4
3·3
2·2
1·1
0
Filtered
Total
ash
Unfiltered.
Total
ash
IV Proteids.
%
1·7
1·5
1·3
1·1
·9
·8
·7
·6
·5
·4
·3
·2
·1
0
Filtered
Total
Peptones
albumoses
albumens.
acid albumen.
Albumoses
%
·3
·2
·1
0
Proto-
Deutero-
Hetero-
Sugar.
%
3
2
1
0
Glucose.
Free HCl
Lactic
Butyric
Acetic
Digestive Power
a. l. q.
facit.
1891
Alcohol
Mucin
Visible fat
Sugar
Starch

bining to the proteids. still incompletely saturated with acid, in the stomach, was rather less in amount to that absorbed along with and combined to the peptones. At the third hour the proportion of acid absorbed with diffusible proteids has increased greatly as compared with the amount still combining with proteid material in the stomach, the amount of combined acid inside that organ consequently falls very rapidly. May be two there was some flow through the Pylorus.

The combined chlorine follows very closely the acidity curve, the total chlorine however is not exactly the same as the total acidity, due as before to the presence of fixed chlorine. The total at the half hour is .4056% as compared with .226% acidity, but .2508% of it is due to the fixed chlorine present. The rest of the curve calls for no remark.

Free acidity and pepsin appear at the hour and a half, or rather between that and the second hour, and rises until the end of the experiment.

The fixed chlorine, considerable at first, falls to .1872% and remains fairly constant thereat.

The total solid curve is different from that in the last experiment, a comparatively small quantity being dissolved at first, only 4%, and, while more becomes dissolved as digestion proceeds, absorption keeps down the total until the third hour, increasing absorption during the last hour, between the second and

third, raising the percentage of the contained Solids — at the third hour the contents were very thick, after which most of the contents of the Stomach are ejected through the Pylorus, leaving some mucous laden fluid, with a small proportion of solids, nearly all of which are Proteids.

The ash gives a similar curve but begins to fall sooner.

The proteids are in greater quantity in this experiment than in the last, as can be explained by the diet. 1·6% to begin with, they sink to 1·17% at the second hour, rise, like the total Solids, at the third hour then rapidly sink to ·5%.

The peptones as in the last experiment are the greatest in quantity and fall rather more rapidly than the total proteids, only a trace being present at the close. The albumoses remain fairly stationary, while the albumens again mount from zero at one hour to ·35% at the third. Again there is only a trace of acid albumen throughout.

The proportions of the three varieties of albumose is not very instructive, but is interesting. Dentero-albumose in excess at the commencement, falls almost to zero then rises again to ·1%, Hetero-albumose, on the contrary, in small quantity to begin with, rises to ·2% and keeps between ·2 & ·1%. The amount of Proto albumose present throughout the experiment is extremely small.

The quantity of sugar, as estimated by Febling's solution, fell throughout the experiment, not a trace being present at the fourth hour.

The Starch taken in the food was present in the form of Erythrodextrin throughout the experiment, giving a light violet with Iodine and Iodide of Potassium. At the commencement the the violet may have been slightly bluer in tint, but very slightly. In the specimens tested at the hour and a half and at the fourth hour only a trace could be detected.

Achroodextrin may have been present as well.

Neither Butyric or Acetic acids appeared, but Lactic was present during the first hour and a half.

There was no trace of alcohol.

Mucin appeared in the last three periods.

The digestive power of the solutions obtained gave very different results, absolutely nil for the first hour, the fibrin used — coloured red with Carmine as Grützner recommends, — was slightly digested during the two next trials, and wholly digested by the fluids of the 3rd and 4th hours. It is seen at once that this coincides exactly with the presence and absence of pepsin, and that presumably the acid present only in a combined state in the first hour has no further digestive power, a point to which I shall return later. (p 283)

Unfiltered; comparison of the unfiltered contents with the filtered shows that naturally the

the percentage of total solids was higher, but that, though a little higher during the first part of the experiment, the combined and total acidity of the unfiltered contents did not rise so high at the second hour, or at the third hour, though at the fourth they did not fall quite so low. Free acid again appeared a little earlier. The Chlorine curves corresponding to the above show the same differences, the fixed chlorine however showing a marked diminution in quantity in the unfiltered specimens, as might be expected, when the solubility of Chlorides is remembered.

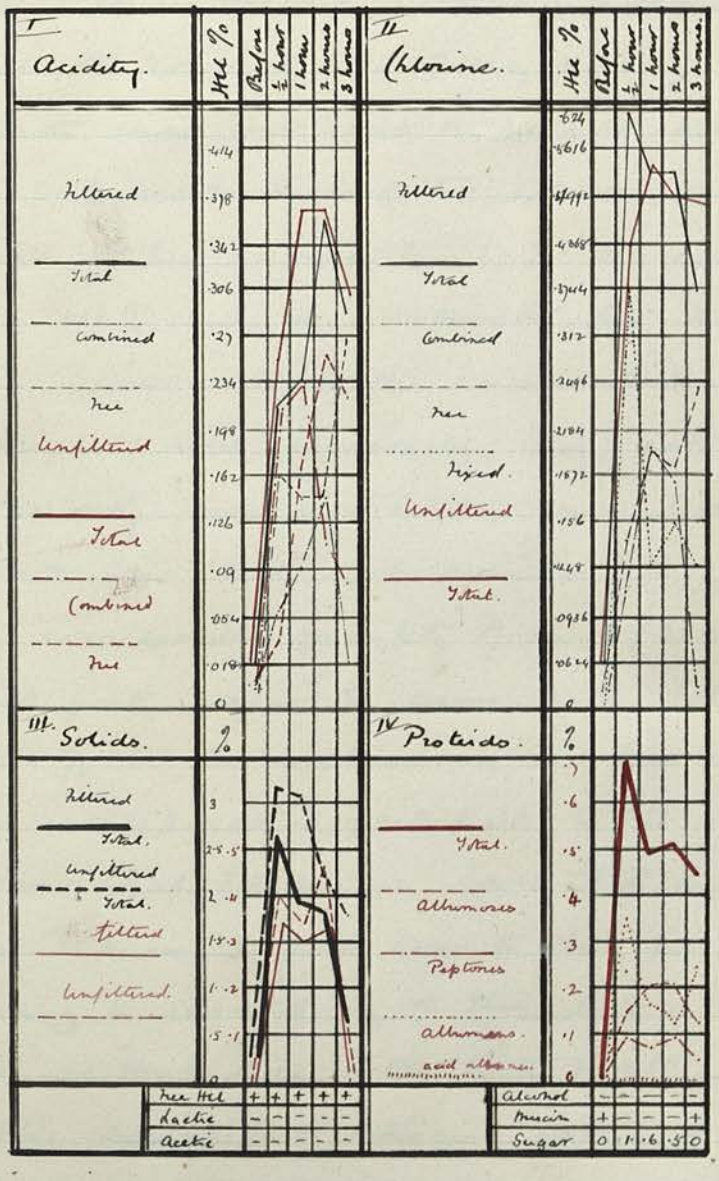
Experiment 24.

I now determined to investigate the stomach contents when a meal principally made up of Carbohydrates had been taken, and for that purpose got my patient to take for breakfast nothing but porridge. I was enable to get sufficient material on one day to examine, but had to extend the experiment over three days, one day getting the contents after two hours; another day at the end of one hour and again before breakfast, without the addition of water, at the half an hour and three hours after, on the third day.

Oat meal, according to König, contains 14·8 % of nitrogenous material, 65 % of Carbohydrates, the rest of fat, inorganic salts and wood fibre.

The results of the experiment is depicted in Chart XV.

Chart XV.



At once it can be seen that the acidities are lower, especially the combined acidity, while the free acidity is proportionately higher.

Filtered; analysis of the results shows, that

the total acidity rises quickly reaching its maximum at the second hour, ·36% then falling to ·288%. The initial rise is made up principally of free acid, the combined acidity only reaching ·144% even at the second hour, and the free acid appears from the very first, unlike the last two experiments. At the 3rd hour the free amounts to ·27% the combined to only ·018%, and it is noteworthy that the patient felt more inconvenienced by this amount of free acid than he had done previously when, with a higher total acidity, more was in the combined state: both in this experiment and in the previous ones.

A considerable quantity of fixed Chlorine in the first part raises the curve of the Total up to ·624% but the combined is low and the free Chlorine corresponds in great part to the free acidity.

The total Solids are lower than in the two previous experiments, and serve to show how much fluid may be secreted by the Stomach in a short time for no fluid was taken by the mouth at breakfast time except that ordinarily contained in stiff Scotch porridge. While the stomach contents when filtered contained 97·5% of water and even when unfiltered 96·8% during the first half hour. The ash is rather higher than in the former cases, as was to be expected.

On turning to the Proteid record it is seen that an extraordinary quantity of proteid material,

considering the character of the diet, appears in the first half hour in solution .7%, though even then it is rather less than half the amount in solution at the corresponding time in the last experiment. The total only falls slightly throughout, it will be noted however that albumens make up the bulk of the Total both at the half hour and at the third hour. Both the albumoses and peptones rise and then fall, the albumoses being the most abundant, while throughout there is only a trace of acid albumen.

The condition of the stomach contents before breakfast can be well studied here because the small quantity obtained on this occasion was siphoned off without the admixture of water.

A slightly opaque fluid, with a shred or two of mucus in it, and with no gastric smell, its acidity was .018% half of which could be driven off by heating, and Günzburg's reagent gave evidence of a trace of free HCl present. The total Chlorides .0624%?, only a trace fixed, and a trace free. The total Solids .04%, with an ash so small that it could not be determined. No Sugar was present, and no Biuret reaction could be obtained.

N.B. The Chlorine was probably only .0312% but the quantity which could be used for testing was so small, 1 cc, that a slight error, even half a drop too much of the Silver would give a difference of .0312% or more. Chlorine however was undoubtedly

present as Fehling's reagent showed.

Unfiltered.

There is not very much difference between the filtered and unfiltered acidities throughout, the combined rises quicker and higher in the unfiltered, while the free also rises quicker but does not reach such a high level as in the other.

The Chlorine curves are similar, only the Total Line being entered on the Chart for the sake of clearness. It does not reach above .4368% in the first half hour, compared with .624%, this of course is due to the excess of salt in solution.

The following are the remaining figures for the Chlorine.

Unfiltered

	Before	½ hour	1 hour	2 hour	3hour
Combined Chlorine	.009	.2691	.2028	.1248	.0456
Free Chlorine	trace	.0117	.2028	.1872	.312
Fixed Chlorine	trace	.156	.1248	.1872	.1248
Total Chlorine	.0624	(.0312) .4368	.5304	.4992	.4826

The combined chlorine falls continuously after the first half hour due probably to the digestion and solution of the Proteids and the consequent preponderance of carbohydrates & insoluble material.

The Solids of course are greater in quantity as is the ash, the solids being in larger proportion at the hour than at the other times, the ash at the

second hour.

Rennet was present on all the occasions, Lactic, acetic and butyric acids absent or only present in exceedingly small quantities. Mucin was detected before breakfast and three hours after.

Sugar as tested by Fehling's solution at 1% at the half hour fell to .6 then .5% during the next two hours and to zero in the third.

No alcohol reaction occurred.

It will be noted also that the stomach evidently had begun to empty by the third hour, in contrast to the former experiments when the process of emptying did not occur until the fourth.

Experiment 25.

The only other experiment I was able to perform on this patient, owing to his departure to America, was not as successful as the former ones.

He had his ordinary breakfast at 8.45 a.m. of bread, coffee and fish, then at 1.30 p.m., four and three quarter hours after, eat eight ripe green gages, spitting out the skins and stones.

The first examination was made half an hour after, the fluid obtained being simply paint brushes dross, seemingly with very little liquid added. It had no gastric smell.

Both the filtered and unfiltered contents were estimated with the following result.

	Unfiltered	Filtered
Total acidity	·918 %	·414 %
Combined acidity	·558 %	·198 %
Free acidity	·36 %	·216 %
Total Chlorine	·3744 %	·312 %
Combined Chlorine	·1704 %	·0936 %
Free Chlorine	·048 %	·0936 %
Fixed Chlorine.	·156 %	·1248
Total Solids	7·2 %	4·55 %
Ash.	·16 %	·15 %
Organic Solids	7·04 %	4·4 %
Proteids.	–	·2 %
Albumen	–	·19 %
Albumose	–	Trace
Peptone	–	Trace
Acid Albumen.	–	None

An hour after only a very small quantity of fluid was in the stomach and was much more dilute it still had a fruity smell.

To estimate the different constituents the fluid recovered had to be diluted with three parts of distilled water and the results deducted.

As far as I could manage, the results are accurate and are in detail as follows;

	Unfiltered	Filtered.
Total acidity	·432 %	·324 %
Combined Acidity	·027 %	·108 %
Free Acidity	·405 %	·216 %
Total Chlorine	·3744 %	·4056 %
Combined Chlorine	·2148	·2808 %
Free Chlorine	·0936 %	·0312 %
Fixed Chlorine	·066	·0936
Total Solids	2·1 %	1·3 %
Ash	·07 %	·1 %
Organic Solids	2·03 %	1·2 %
Proteids	—	a trace.

Uffelmann's test for lactic acid gave a positive result each time but this was probably in most part due to the vegetable acids present, malic, citric etc. The amount of sugar was unluckily not estimated.

The principal feature of the experiment is the large amount of acid both free and combined present, only a very small proportion of which consists of Chlorine. And that, notwithstanding, the patient felt no discomfort therefrom, although he assured me told that, if the fruit had been unripe, he would assuredly have suffered great pain.

I performed also one or two corroborative analyses on other patients, but as they could only get up the stomach contents with difficulty the experiments were necessarily limited.

Experiment 26.

A patient, King about 30 years old was in Ward 24 of the Royal Infirmary suffering from a chronic nervous dyspepsia very like in character to that of the preceding case.

His stomach contents were evacuated one hour after tea, a meat tea consisting largely of Proteids. The analysis was performed in the same way as the preceding, both of the filtered and unfiltered.

King. ½ hour.

	Filtered	Unfiltered
Total acidity	·198%	·252%
Combined acidity	·18%	·234%
Free acidity	·018%	·018%
Lactic acid	·04272%	·078%
Acetic acid	nil	nil
Butyric acid.	·018%	·018%
Total Chlorine	·3744%	·4056%
Combined Chlorine	·13728%	·156%
Free Chlorine	nil	none
Fixed Chlorine	·23712%	·2496%

	Filtered	Unfiltered.
Sugar	1·404 %	·527 %
Alcohol.	?	?
Total Solids	3·4 %	3·8 %
Ash	·1 %	·1 %
Organic Solids	3·3 %	3·7 %
Proteids		
Albumen	·0867 %	–
Peptone	383 %	–
Albumose	·18 %	–
Acid albumen	? trace	–

Organic Solids ·3·3 %

Sugar	1·404 %
Proteids	·6497 %
Chlorine combined	·13728 %
undetermined	1·20902 %
	3·3 %

Proportion of acid combined to proteid, 27·7 %.
Proportion of Chlorine combined to proteid 21·1 %.

—//—

Comparison of the amounts present in this case with those in experiment 23, (chart XIV. shows that the total solids are less, that the Proteids especially are smaller in amount and that

therefore the combined acidity is also lower. The proportion between the filtered and unfiltered contents is the same in both. In the present case the total solids chlorine is under, but the fixed chlorine is above the previous amount at the half hour.

In all then this experiment corroborates the previous ones with reg and to the proportions between the different constituents.

One point however should be further noted, the presence of a comparatively large quantity of Lactic and Butyric acids in the wash, due probably to some fermentation in the stomach.

Experiment 27.

A patient Hanson, (with a dilated Stomach) was given a meal of bread and milk alone, half an hour after, the contents were removed and analysed.

Filtered.

Total acidity	·162%	Total Chlorine	·3432%
Combined Acidity	·162%	Combined Chlorine	·0687%
Free acidity	0	Free Chlorine	·0.
Lactic acid	·0933%	Fixed Chlorine	·2745%
Butyric acid	0 ? trace.		
Acetic acid	0	Proteids	4·47%
Acetates	Present	Albumen	1·43%
		Albumose	·391%
Total Solids	10·3%	Peptone	·541%
Ash	·56%	Acid albumen	trace
Organic Solids	9·6713%	Sugar	Present
		Alcohol	absent.

The contents were very concentrated, the percentage of proteids very high, with, although only a small amount of combined acidity, a very considerable quantity of Peptones and albumoses. On investigation however, I discovered that the remnants of his previous meal had probably not entirely left his stomach at the time he took the bread and milk. Here again there was a considerable amount of lactic acid present. On testing for the ethers of the organic acids there was a slight trace of Butyric Ether, none of acetic, but on testing for Acetates they were found to be present in small quantities

Experiment 28.

Through the kindness of D.r Mackenzie, Resident physician in D.r Bradenridge's Wards I was enabled to analyse the Gastric contents of a case in which there was a considerable quantity of Acetic acid present.

I received the contents of his stomach on two successive days, drawn off 3½ hours after tea time, the first day after bread and milk, the second after bread and milk and a Kippered herring.

I tested them both in the unfiltered and filtered state. The details are as follows;

No 1, is after bread and milk,

No 2, after bread milk and a herring.

—

	1 Filtered	2 Filtered	1 Unfiltered	2 Unfiltered
Combined Acidity	.306 %	.45 %	.288 %	.468 %
Total acidity	.432 %	.504 %	.45 %	.504 %
Free Acidity.	.126 %	.054 %	.162 %	.036 %
Lactic acid	—	—	—	—
Acetic acid	.0324 %	.0228 %	.0372 %	.0048 %
Butyric acid.	—	—	—	—
Total Chlorine	.4368 %	.5304 %	.4992 %	.5304
Combined Chlorine	.19344 %	.1368 %	.21216 %	.156 %
Free Chlorine	.0936 %	.0312 %	.1248 %	.0312 %
Fixed Chlorine	.14976 %	.3432 %	.16224 %	.3432 %
Total Solids	2.78 %	4. %	3.52 %	4.08 %
Ash	.3 %	.38 %	.24 %	.4 %
Organic Solids.	2.20656 %	3.4952 %	3.06784 %	3.524 %
Proteids	.776 %	.86 %		
Albumen	.18 %	.34 %		
Acid albumen	Trace	Trace		
Albumoses	.37 %	.1		
Peptones.	.226 %	.33 %		
Sugar	.42 %	1.02 %		

From this it is seen that the herring makes a considerable difference in the acidities and that especially the fixed Chlorine rises. Everything else rises in proportion, the solids and proteids etc.

Although the Acetic acid present in a free state

is not in large amount, being calculated from the difference between the free Chlorine and free acidity as if Lactic or Butyric acids were present, there was a considerable quantity in the form of acetates and probably combined with Proteids also, judging by the depth of colour formed on using Uffelmann's reagent or Liquor ferri perchloridi as tests.

This patient was the subject of a very chronic dyspepsia with hyperacidity, the hyperacidity being however due more to organic acids than to Chlorine.

Consideration of the results obtained by the analysis of the contents of the Human Stomach at different hours.

The first thing that struck me after analysing these fluids was the similarity between the acid and chlorine curves in general of both these natural and the artificial digestions. The curve rises quickly in both and as a rule in both begins to fall about the third hour, when in fact the amount of acid seized by the Proteids is less than the quantity of acid and proteid diffusing through, or being absorbed, the fall however, as is only natural, being slower in the artificial digestions.

Secondly, Hayem and Winter's observations on the small quantity of free Hydrochloric acid present during digestion is corroborated. And

the exact reason of its apparent absence during the first part of digestion established.

My opinion of the matter is this. A small percentage of HCl is constantly, from the very commencement of gastric digestion, being secreted. This at once combines with proteids, the combination obscuring the reactions peculiar to a free acid. The intimate nature of the combination I enter on more fully elsewhere (p. 380), but I strongly question the accuracy of Mathieu, Richet, Hayem or Winter's views as to its being an amido-acid, a hydrochlorate of leucin. Without pepsine HCl even if it saturate the proteid molecule can not produce any appreciable change in it, save the formation of some acid albumen.* With pepsine present, however, the case is different, for as the acid saturates the albumen or globulin molecule, — a compound molecule like starch (cf Bunge [6]), —— part of the molecule becomes a simpler proteid. If free acid be still present this process may go on until peptones are reached. The essential part of the process is, I believe, a splitting up of a complicated molecule by means of free acid, in the presence of a ferment, into simpler molecules, each of which has a higher saturation point for acid, a greater acidity for it. These molecules in turn, when fully saturated, split up in a similar manner into still less complicated bodies.

X. Kühne has said that HCl without pepsine is capable of changing a small quantity of proteid into peptones, that is, hepatones and albumoses.
(See below p. 230)

This theory coincides with the course of the acidity in the stomach. At first the percentage of Chlorine combined to Proteids is small, chiefly because all the Proteid has not been attacked by the acid, but as digestion goes on the percentage of acid combined with albumenoids, or of the Chlorine similarly combined rises, and that although Peptones with their acid are being absorbed. That is to say then that the albumenoids resulting from digestion probably take up more acid than the original albumen or globulin.

On comparing my results with those of Cahn tabulated on p. 39 et seq, I find that, while in some respects similar, in others they differ considerably. For instance the curves of the Solids expressed in percentages rise rather than fall during his experiments, while the variations of the Hydrochloric acid are very small, rising only slightly until the third hour in one experiment, and only .08° by the second hour in another. He found that the amount of acid albumen remained almost stationary .11 — .16%, I only found traces of this albuminoid in any of my experiments on man. The amounts of peptone and albumose which I could separate out were far below Cahn's figures, who found 2.18% of peptone, using Kjeldahl's method in the contents of the stomach, the Total Solids of which only reached 2.81%!

I have in addition to his investigations, included tables of the different acidities and chlorine, of the ash, and of the various forms of Proteid.

From his investigations I am believed that most of the stomach contents were expelled into the Duodenum with the Proteid constituents peptonised, that is that peptones are not absorbed by the Stomach in any great quantity

I combat this view on the following grounds;

1. The course of the combined acidity and of the quantity of Proteids present is so similar in the digestion as occurring in man and in dialysing tubes, that probably the same cause has some influence in both. In the dialyser only peptones can and do diffuse carrying the combined acid with them. (cf p. 108) In natural digestion the peptones can diffuse and may be absorbed as well by the cells of the stomach wall without the actual aid of diffusion.

2. On separating the albumoses from the peptones it is seen that, while the peptones tend to fall as digestion proceeds, the quantity of albumose remains fairly constant to the end of digestion.

That is to say that, in the course of the production of peptones from albumens, albumoses are being constantly formed and as constantly are further acted on by HCl producing peptones. The peptones are absorbed at a certain rate, and as the original

amount of Proteid diminishes so the albumoses formed from them diminish, but more slowly and often not until close on the close of the digestive process.

3. An objection, which could be raised to any deductions drawn from percentage results, due to the inflow of fluid during digestion and consequent lowering of the amount of proteids obtained, or of total solids, is negatived by Cahn's results, for he withdrew the whole contents of the stomach at each period, a proceeding I found it impossible to do in man, and estimated the absolute quantity of Total Solids, both dissolved and undissolved.

He found these to diminish as the digestion advanced, and the diminution is so marked in one of his tables, (p. 41) — from 40·73 gr. at the half hour to 15·82 gram. at the second hour, or 11·63 gram at the 2½ hours — that it cannot simply be due to absorption of inorganic salts. And unless the material which has disappeared has passed through the Pylorus, which I do not believe, it must have been absorbed.

4. As a rule I found the Total Solids diminished in quantity as digestion went on, in Experiment 23 the dissolved solids increase slightly, the total unfiltered decrease, the decrease was generally more than could be explained merely by the absorption of inorganic salts. In considering this, I must

note that as I withdrew a certain amount of the contents at each half hour or hour the quantity of solids left was necessarily smaller, on the other hand however, I noticed that the consistency of the fluid seemed only to vary slightly and it appears to me as probable that with a particular meal the amount of fluid present does not increase much during digestion, absorption and diffusion keeping the contents at a fairly constant concentration, even if a large quantity of fluid be taken with the food.

5. Moritz[116] who performed some very similar experiments to mine, but which were not so full, washed out a boy after meals and found the Total Hydrochloric acid most at the third hour, .4%, about the same at the fourth hour and then disappeared slowly. He seldom got any reactions for free HCl until the second hour, but they became marked afterwards. The albuminoids were most at the third hour, diminished rapidly after that. Moritz included all acids in his total HCl and had no means of differentiating between combined and free HCl quantitatively. He advises a re-examination of any specimen of stomach wash with a strong tinct reaction and no free HCl. an hour or an hour and a half after. His work then gives, as far as it goes, much the same result as mine, although in their original form they afforded little

opportunity for useful deduction.

6 Considering the relation of my work and that performed by Hayem and Winter I confess that they are on the same lines but I contend that I have carried the matter forward, in some degree at any rate. In my abstract of this work in the Chap. devoted to the history of the subject, p. 34 I have noted the principal conclusions these authors have come to and criticised their work in a general manner. I think I should here note my conclusions, from the foregoing experiments, as to the correctness of their views. Their proposition that Hydrochloric acid combines with proteids and that when in that condition it does not volatilise like pure HCl I hold as proved, and regard it as a most pregnant fact, a fact which should be of immense use in future when investigating the contents of the Stomach both quantitatively and qualitatively. The exact form of combination however cannot be, in my estimation, a combination with Leucine, but this point I will investigate more fully later. These authors point out the curves of the Chlorine in its different forms during digestion in the dog, these curves I have obtained and corroborated from digestion in man, also however, pointing out the more exact relation of the combined Chlorine curve to the amount of proteid undergoing digestion.

Their method of working through exact is unduly cumbrous and long and unsuited to ordinary cases and I believe that the method which I have indicated especially with regard to the acidity and chlorine before and after evaporation is, though less correct, exact enough for general purposes, and gives the examiner a very good basis to found a decided diagnosis on and serves as a sound indication of the treatment applicable. But I also claim that my experiments have shewn that judging from one meal is erroneous, especially if the time be not specified, and that to judge the state of the digestive power from a test meal of "tea and a piece bread" given probably at the time when a larger meal is usually taken is not judging from proper grounds. Hayem and Winter class their patients, and they give records and analyses from many, from one analysis each at a time, after food, which is not noted. My own feeling is that no-one can rightly appraise the power of the stomach or the state in which that viscus is in, unless he has examined the contents at a certain time after the digestion of a regular meal and, having ascertained the relative quantities of acids and solids, especially the proteids, bearing also in mind the variations which normally occur at the different hours after the meal, has found out the proportion of acid free and

acid combined to the proteids present, and has also estimated the amount of organic acid in the fluid. The examiner, of course, knowing the character of the meal taken, will know what variations to expect, that is, after porridge he would find the free acidity predominating or after vegetables alone — the stomachs of vegetarians must, after some years of experience of this sort of diet, become sluggish and inactive from the small amount of work they are called on to perform — while after a pure meat diet he might find no free HCl after three hours even, though in this case he should not jump to the conclusion that there is Cancer present without giving the patient a meal in which proteids only build slightly.

In fact in cases in which from absence of free HCl in the stomach contents Carcinoma of the Stomach is suspected I would recommend the adoption of a plan which I use, that is giving the patient a purely amylaceous meal and again testing the contents. If there is still an absence of free HCl or a very notable diminution of it, I consider it a very suspicious sign.

(To illustrate how much may be inferred from an examination of the stomach contents) may adduce the following. I was sent a specimen of a stomach washing of a case said to be on milk diet alone. The fluid, which must have been

drawn off about the fourth hour, contained only very small fragments of solid material but had a peculiar odour which however was greatly masked by the usual Gastric smell. On testing the contents I found the proportion of combined acid higher than it should be with a purely milk diet and also that the fixed chlorine and ash were greatly in excess. I diagnosed a salt or red herring and on cross examination the patient admitted having partaken of one brought in by a friend to him.)

With regard to the point brought forward by Hayem & Winter as to the large quantity of fixed chlorine obtainable from the stomach contents — they experimented in this case on dogs — when only distilled water had been ingested I have little data to go on. I tried an experiment on a patient by giving him a drink of distilled water but failed to siphon sufficient fluid off to test and even that was principally saliva.

I examined however the contents of Begbie's stomach, — the patient I did the principle experiments on, —— before he took any food on two different occasions, the stomach being practically empty on both. The fluid obtained was small in quantity very slightly acid and only contained a very small quantity of chlorine and of that only a trace fixed. Even part of this fluid may have been

secreted by the mucous membrane of the stomach irritated by the end of the tube, the rest being composed of swallowed saliva. In the second case the proteids amounted to very little, they were not estimated in the first, that little probably due partly to mucin, although traces of either albumose or Peptone were present.

In this case then the stomach was not absolutely empty after a 12 hours fast but contained traces of proteid and acid dissolved in a small quantity of water. The fixed Chlorine was very small in amount.

Now as I said on the last page Hayem and Winter found the fixed Chlorine to increase up to a certain point in the digestion of distilled water in the dog. They used an animal in whom a gastric fistula had previously been made, and obtained the following quantities of chlorine after giving 400 gr. of distilled water by mouth.

Time	Total Chlorine.	Fixed Chlorine.	Combined Chlorine
10 min	·0657	·0438	·0219
30 min	·073	·0657	·0073
60 min	·14	·116	·03
80 min	·219	·153	·066
100 min	Stomach empty.		

There was no free HCl at any time.

On examining the above chart one is at once struck with the fact that there is no free HCl present

and only a very small quantity of combined acid per cent. Arguing from my results I would say that there could only have been an infinitesimal secretion of Gastric juice, for if any quantity had been secreted, where had the free acid disappeared to? I do not believe that anyone will support a theory which depends on the secretion of the almost pure Common salt solution by the Gastric mucous membrane, the amount of combined chlorine never rising above $\frac{1}{3}^{rd}$ of the fixed. Now the Saliva is known to contain mucin and small quantities of serum albumen and globulin, and, although mucin is not digested in the stomach, (cf Moritz[116] I have found that HCl combines with it, so that the swallowed saliva may cause the secretion of a small quantity of HCl from the Stomach glands sufficient to combine with the proteids in it and to digest those that are digestible. Saliva also contains from .2 to .3 % of salts chiefly Chloride of Sodium. Again we know that pure water is very rapidly absorbed from the stomach, so that probably, during the time occupied by the experiments, most of the original water had either been used for the previous testing or had been absorbed, causing a progressive rise in the percentage of the salt present until it came close to what is present in normal saliva (.15 %). In fact I utterly and entirely disagree with the authors on

on this point.

7. Although there is a great similarity between the figures in the artificial experiments and in the analyses taken from man it must be remembered that the processes are, in reality, widely dissimilar. It must not be argued that, because simple diffusion of acid in the one case gives analogous results to those obtained in the other, the steps of the process are the same. The real point lies in the fact that in both cases Hydrochloric acid is added to the substance to be digested in small quantities but constantly. In the artificial experiments performed with the aid of dialysers osmosis is the sole factor; in nature secretion is the chief if not the only agent. The results closely approximate. The methods differ.

It is from this constant addition of the Hydrochloric acid also that digestion experiments in dialysers are so much more satisfactory than those conducted in flasks. The removal of the products of digestion is not nearly so important as Sheridan Lea imagines.

8. The proteids in the filtered contents fell as a rule in all the experiments, the only exception being in the amount of albumen. This proteid rose towards the end in each case. As the test employed for its determination also precipitates mucin, and from the fact that during the first hour

in all the experiments no proteid, coagulable by heating after the addition of Acetic acid, was present, the probability is that the substance here called albumen was really mucin. That mucin is not digested in the stomach is corroborative of this.

Acid albumen in most cases was only present in minute traces. Albumoses kept much the same in amount throughout each experiment.

Peptones were generally greatest in quantity at the beginning, either at the half hour or at the hour, falling rapidly after. But in this particular the artificial experiments differed from the others. For in them the peptones increased till the third hour or so; and then fell in amount.

Indeed the proteids as a whole in the artificial experiment (Chart X.) rose rather than fell in quantity as the experiment proceeded.

9. The influence of different forms of diet on the rate of increase of acids, and also on the conditions in which the acids were present, was noticed in the experiments on man.

In the first part I showed that, in artificial dialyser experiments, potato and glucose had little power of attracting hydrochloric acid from outside. In the latter part of this section the same is seen to be true in man. With a diet largely proteid the free acidity does not appear until late, the combined acidity rises high. After a

meal principally composed of (carbohydrates the free acidity appears sooner, and is in greater quantity. The combined acidity being on the other hand proportionately less.

The (onclusions I would draw from the foregoing experiments are as follows:

1. Free HCl is secreted by the stomach glands from the moment in which food enters the viscus. (cf 7. p179)
2. First stage of gastric digestion, during which no free HCl is present, but the total acidity constantly rises. The stage of organically combined HCl, with, frequently, the addition of traces of free organic acids.
3. Free HCl appears in the stomach contents, the time of its appearance varying with the composition of the food, with its concentration, and with the state of the gastric mucous membrane. The time varies between the first half hour to the second or third hour.
4. Second stage of gastric digestion, with free and combined HCl present. Acidity rising.
5. Third stage of gastric digestion, both free and combined HCl present, total acidity falling.
6. The first stage at the beginning can allow

probably the amylolytic action of the saliva to go on for a short time. (cf p. 277.)

7. The HCl secreted at first combines at once with the proteids present in the food.

8. Hydrochloric acid organically combined is less antiseptic than pure HCl. (cf p 352)

9. The Total solids both of the filtered and unfiltered contents fall per cent from the commencement.

10. The acidities per cent. differ in the filtered and unfiltered contents. The total acidity is lower in the filtered contents, the combined is generally higher, the free lower, than in the unfiltered.

11. The inorganic salts diminish per cent. from the commencement.

12. There is generally a great excess of fixed chlorides at the beginning of digestion, due to ingestion of NaCl and other chlorides with the food, this excess soon disappears.

13. The total proteids per cent. fall during digestion.

14. Albumen (probably mucin) increases per cent, albumoses remain stationary while the peptones diminish largely per cent.

15. The different forms of albumose (Chart XIV) vary little, proto-albumose is least in amount, the hetero- and deutero-albumoses are very similar in amount.

16. Microorganisms are present in large numbers at the beginning of digestion, the numbers diminish as digestion goes on.

17. The stomach contents have no further digestive power unless there be some free HCl present.

18. Digestion in the stomach is very similar in its results to digestion in a dialyser, but in the latter absorption does not go on so quickly.

19. The great factor in causing the courses of the acidities and chlorides to be similar both in the stomach and in dialysers, and at different times after varying diets in the same stomach, is the constant accession of free HCl in small quantities to the contents in the viscus or dialyser tubes.

20. The usual percentage of acid present in the contents of the stomach as given in text books on physiology is very misleading, unless the time after the meal and the nature of the meal be taken into consideration.

The total acidity may be from .108 to .36%
The Combined acidity from .072 to .324%
The free acidity from .018 to .09%.

But they vary so much from the above mentioned causes that it would be futile to lay down any hard and fast limits.

21. The free HCl is seldom over .09% at any hour after a proteid meal. It may rise to

·162 or ·27 after a meal chiefly carbohydrate in character.

c. Types of Gastric disorders.

These notes are taken some from my own experiences, others from the journals of Ward XXIX, for which I have to thank S. Merrihead. I have included no case which I did not see myself or which I did not examine either clinically or analytically at S. Merrihead's request.

Many of the estimations of acidity were made before I could differentiate between free and combined acidity quantitatively. Most of them only give the total acidity, and the fact whether free HCl or free organic acids were present or not. The methods were the same as before, titration with Phenol phthalein, & testing with Uffelmann's and Günzburg's reagents.

The following types are represented

1. Hyperacidity. HCl in excess.
2. Absence of free HCl.
3. Organic acids in excess
4. Cases of suspected Gastric Ulcer
5. Anaemia.
6. Dilated Stomachs.
7. The dyspepsia of young women not necessarily anaemic.

I only give very brief notes of the outstanding characteristics of each case.

1. Hyperacidity, HCl in excess.

a.

Robert Bruce, 41 years old, had a dilated stomach reaching to 1½ in. of the pubis, the contents of which were always extremely acid. Seldom were any Sarcinæ discovered. The only treatment which gave him any relief was regular lavage. He soon became an adept at this, and either washed his stomach out or siphoned off the contents every evening, about four hours after food.

A pale, emaciated man, he suffered great pain after every meal especially if the food were chiefly of a carbohydrate nature.

Analyses and experiments.

Oct. 20. 88, the stomach contents were .54% acidity five hours after food, free HCl present in considerable quantity. The urine .154%.

Oct 24, Wishing to find out the effect of alkali on this acidity I gave him Sodii Bicarbonatis ʒii at 2 p.m. after his dinner, he had some tea at 4 p.m, and siphoned off the contents of his stomach at 9 p.m, five hours after, the acidity then was .456% mostly HCl; urine .036%.

Oct 26, I repeated the above; when the stomach contents were .5364%; the urine .068%.

Oct 28. I gave the patient ʒi ℈x of the Bicarbonate every hour from 2 to 6 p.m., he was

washed out at 9, two hours after his tea when the acidity was ·522% ; urine ·04161%
Oct 29. After similar treatment, ·41% ; urine not tested. The XX gr. today were given from 3 to 8 p.m. that is that an hour after he had taken gr XX of Soda bicarbonate the gastric acidity was very little influenced.
Oct 30. He was given gr XX again from 3 to 8 p.m. Acidity ·574 ; urine ·0861%
hour 7. On this day I gave him ʒii of the Bicarbonate four hours after tea, washing him at the fifth hour. The acidity had fallen to ·1374% but the acidity of the urine had risen to ·456%.
hour 13. No Soda was given, acidities, Stomach ·48% ; urine ·153%.
hour 15, 16 and 19, three doses of gr X each of Bromide of Lithia were given with no effect on the acidity of the urine or stomach; which were, stomach ·45% to ·48%, urine ·09% to ·144%.

The chief things noticeable in this case are the large stomach, the large amount of HCl, causing severe pain, the small influence alkalis have on such acidity, two drachms one hour before not being able to neutralise it. And the varying acidity of the urine, which was always passed at the time of the washing out, an acidity which varied inversely with the stomach acidity

The doses of Soda relieved his pain but only temporarily, the excess of acid soon bringing it back.
Diagnosis, fibrous constriction of the pylorus, dilated stomach, hyperacidity. Little or no fermentation.
Treatment; Lavage, a pill containing the Hydrargyri Iodidum Viride and Carbolic acid, with nervine tonics.
Result. Improvement.

6.

David Langlands, 41, with a dilated stomach, vomiting, sometimes with blood, melaena, slight tenderness in epigastrium. Might have been Cancer disproved by examination of stomach contents which were very acid, no organic acids.

June 3, /88, .48% Urine slightly acid.
June 8, /88 .6% Urine alkaline.

His stomach contents were drawn off before breakfast on two occasions, but on neither was any HCl found in the free state.
Diagnosis, Hypersecretion of HCl, probable erosions of the mucous membrane of the stomach. The hyper secretion probably paroxysmal, and not occurring during the night.
Treatment, Lavage, Morphia, Calomel.
Result; Great improvement, hardly any pain, patient gained weight.

c.

George Galloway, 28, with a dilated stomach, had been ill for a considerable time. No cause further than a most obstinate constipation. Great pain after food, with tenderness in the epigastrium. Paroxysmal vomiting, the vomit on occasions containing blood, it generally also contained numbers of Sarcinæ. Acidity very high, contained however organic acids as well as HCl.

July 31st Stomach contents .79% HCl.
August 13th " " .77% HCl.

Diagnosis, similar case to last.

Treatment, Constant washing out, hyposulphite of Soda. Ergot and regulation of the bowels.

Result, Great improvement.

d.

John Penman, 34, a miner had been ill for five years, the stomach somewhat dilated going two finger breadths below umbilicus. The contents though not so acid as in the last three cases had an excess of HCl; only once was a trace of Butyric acid found. The acidity varied from ~~.021~~ .189% to .4095%. The urine was less acid than normally, varying from .016% to .024% or about 2.5 gr HCl per diem.

This case was greatly benefited by washing out the stomach regularly.

The diets given to this patient were as follows

1. Milk, eggs, toast, meat. Good appetite and relish, but vomited after it
2. Milk, and puddings, still sick.
3. Peptonised foods, no sickness.

Porridge, fresh bread, rice, sweet foods, vegetables could not be borne.

The urine in this case deposited numerous silky crystals, forming a layer of nearly 1 inch at the bottom of a urine glass. These crystals were of organic origin, and answered to many of the tests for Tyrosin. There were no Leucin balls.

2.

William Graham, 64, quarryman, had great pain ½ hour to 1 hour after food, especially bad after rice, porridge or new bread or potatoes and other vegetables. Old bread, arrow root and soups do not increase the pain. Bowels very costive. Vomit yellow and bilious. Great thirst. Stomach contents hyper acid, from ·316 to ·47 HCl, no organic acids, free HCl copious.

He was given for food, porridge, milk, eggs and bread and butter for breakfast, dinner beef-tea and old bread, and for supper bread and milk. His stomach, which was not dilated, was washed out every evening

His urine was neutral or very faintly acid and

contained very similar crystals to the last case.
No Leucin balls. See photograph.

This patient was considerably benefited.

J. James Watt, 37, a carter, complaining of severe pain in the stomach, flatulence and constipation. For eight years has suffered from pain in the epigastrium. His stomach is a little enlarged, the contents hyperacid, .44% HCl, With regard to food, vegetables were the worst offenders, cornflour however and toddy or laudanum gave him relief. Fish, mutton or porridge were tolerated. Urine alkaline, no deposit. Liver normal. He was put on a similar diet to the last case, except that he was given a sandwich of bread and beef peptonoids to eat at night if suffering pain. Proteids relieved the pain. The acid in the Gastric contents was almost solely HCl. The acidity of the urine as a rule varied with that of the Stomach contents.

From these cases, the number of which I could multiply, it is evident that, in the class of Gastric derangements in which hypersecretion of HCl plays the chief part, vegetables must be avoided and proteids recommended. It is seen that the pain generally comes on when the acidity is at its highest, and that removing the acid contents removes the pain. Hoematemesis with hyperacidity

Photograph of crystals found in the urine of Graham, see opposite.

may either be due to Gastric ulcer, erosions from the excess of acid, or, as Rosenheim has pointed out; in the early stages of cancer cases which have followed on simple ulceration of the stomach mucous membrane.

The urine in many of these cases varies inversely with the stomach contents. Indeed in many of these cases it is possible by estimating the acidity of the urine to come to a very shrewd idea of the state of the stomach contents.

The occurrence of the crystals in Graham's and Penman's urine I return to later.

2.

Types of the want of free HCl.

a. Cancerous.

The following cases in which HCl was absent in a free state were confirmed by post mortem examination

Beveridge, Cancer of stomach and liver, acidity very slight, no free HCl.

McGee, Cancer of the pylorus. no free HCl.

A. Young, Cancer of stomach. no free HCl.

McLeod, Cancer of the duodenum, head of the pancreas and involving the stomach but only slightly, the slightest trace of free HCl.

D. A, 61, a gardener, had been sick months ill. Bowels very constipated,

stomach somewhat enlarged. Analysis showed.

	Stomach Wash. Acidity %	Free HCl	Lactic	Butyric	Urine Acidity
1	·072	–	+	–	
2	·108	–	+	+	
3	·027	–	+	+	
4	·036	–	+	–	
5	·036	–	+	–	
6	·009	–	+	+	
7	·172	–	+	+	·048%
8	·054	–	+	+	·126%.

The acidity was very slight, no HCl absent on all occasions with considerable fermentation and the presence of organic acids.

A. McPhail, aet. 60, a labourer, a year ill, shows the 9 characteristic points of gastric cancer. 1. Has great epigastric pain. 2. Has vomited blood. 3. Has had melæna. 4. Has a swelling, painful on pressure in the epigastrium, 6. Has lost weight. 6. Is above 40. 7. Has an increased quantity of urea in his urine, considering his diet. 8. The acidity of the stomach juice was decreased, no HCl absent. 9. There was some increase of pigment in the urine. Besides these signs secondary tumours appeared.

The examination of the gastric juice gave the following results;

Stomach Contents Acidity.	Mu HCl,	Lactic	Butyric.	Urine Acidity.
·216	−	+	±	
·216	−	+	+	+
·16	−	+	+	+
·172	−	+	+	+
·136	−	+	+	+
·294	−	+	+	−

6. Anaemia.

Lessie Worcester, 17, waitress, general weakness, loss of appetite, inability to retain her food, Headaches and heatlessness. Is anaemic.

Blood Jan 25 1889 Red blood corpuscles 2,155,000

Haemoglobin 32%

Feb 2 1889.

Red blood corpuscles 2,400,000

Haemoglobin 40%.

Stomach contents. No per HCl, a considerable amount of Butyric.

Feb 13. 1889

Red blood corpuscles, 3,200,000

Haemoglobin 50%.

Feb 20, 1889

Red blood corpuscles, 3,410,000

Haemoglobin 62%

Stomach contents more acid and

contained some free HCl.

Feb 28th 1889

Red blood corpuscles 3,375,000.

Haemoglobin 65%.

Her digestive functions were now much improved and free HCl was found in the stomach wash. She had been treated with an effervescing iron mixture.

The blood was counted by an ordinary Haemocytometer.

James McBeath, 25, machinist. Anaemic, with also dyspepsia, pain after every meal and vomiting. No blood in the vomit. The pain comes on about half an hour afterfood and is relieved by the sickness. The form of food made little difference.

Analysis. 3 hours after tea, on four days.

Stomach contents.

	Acidity	HCl free,	Lactic.	Butyric.
1	.16	±	+	±
2	.19	±	+	—
3	.18	—	+	—
4	.16	±	+	—

Perhaps a trace of Acetic acid in nos 1 and 3.

3. Organic Acids in excess

a.

James Smith, a railway fireman, suffering from pain after food, generally about an hour after; followed by vomiting. The matter ejected was sour and greenish. He had been ill for four months. The pain was worse after meat, fat, and puddings. His stomach was a little large, his bowels somewhat constipated. He was put on a milk diet at first and his stomach was washed out every evening, five hours after his last meal.

Analyses:-

Stomach Wash.				Urine.
Acidity;	Free HCl,	Lactic,	Butyric	Acidity
.18 %	+	+	+	+
.198 %	+	+	±	−
.18 %	+	+	±	−
.198 %	+	+	−	−

(His diet was now changed, he was given meat, porridge and milk, and a meat sandwich at night.)

.098 %	+	+	−	.019 %
.108 %	+	−	?	.072 %
.09 %	+	+	±	
.126 %	+	?	?	.09 %
.116 %	+	+	+	.0198 %
.18 %	+	±	−	
.171 %	+	+	±	.027 %
.126 %	+	?	?	.036 %

The treatment adopted was dieting as above, washing out the stomach and the exhibition of antiseptics. It will be noticed that as the case went on the organic acids diminished somewhat. The Sarcinæ which were numerous at first also became less in number.

The antiseptic used was the green iodide of mercury made into a pill with some carbolic acid and soap.

In this case the acids present in quantity were Lactic and Butyric, in the following case Acetic acid was the principal acid present.

6. Mrs Blackwood, 23 years old, had lately suffered from gall stones. She complained of pain in the stomach, great heart burn, much wind and vomiting. The pain came on about half an hour after food. She was markedly hysterical. She was washed out and given bismuth and Soda with considerable benefit.

Analyses.

Stomach Wash, 4 hours after tea.

	HCl.	Acetic.	Lactic.	Butyric.	Acidity.
1	±	+	±	–	·144 %
2	±	++	±	–	·18 %
3	+	±	–	–	·036 %
4	±	+	±	–	·252 %
5	±	+	–	–	·126 %
6	±	+	–	–	·054 %

It is noticeable here that only the only occasion on which the reaction for acetic acid was faint (no. 3) the reaction for HCl was distinct, while the total acidity per cent. was small. The chief part of the acidity on the other occasions is then, probably, Acetic acid.

Acetic acid fermentation is commoner among patients who are anæmic and dyspeptic at the same time, than in other classes.

Another case of a similar character to the last is noted and the stomach contents analysed on page 157 above.

There it will be seen that the amount of acetic acid present has been estimated quantitatively. I was enabled to do that with certainty owing to the absence of Lactic and Butyric acids. The difference between the free acidity and free chlorine gives the amount present.

But here it must be noted that in this case the total amount of acetic acid present was probably considerably greater than the amount of free acid (·03%). Acetates give the brown colour with Uffelmann's reagent, but neither influence phenol phthalein, nor form acetic ether with alcohol and H_2SO_4. Here the colour struck with the ferro-ferric solution was darker than the amount of free acetic acid would lead one to expect and after evaporation this still persisted

Before evaporation however Acetic Ether could be formed, after none was observed. Then acetic acid then had been driven off by evaporation to dryness, leaving acetates, which are not decomposed at 38° Centigrade, and which gave the brown colour with Uffelmann.

4. Cases of suspected Gastric Ulcer.

a. Cases which probably were gastric ulcers.

I have inserted the word "probably" because no post mortem was made on any of the cases, nor of them being fatal.

Haematemesis with increased acidity of the gastric contents I regard as pathognomonic of either gastric ulcer, or of the simples erosion of the mucous membrane.

Haematemesis with normal or moderate acidity is indicative of congestion, either from local hepatic congestion, or from the general congestion following heart disease, etc.

Haematemesis with decreased acidity, especially with the absence of free HCl 3 or 4 hours after food, points to malignant disease of the stomach especially of the Pylorus.

Cancers however of the pancreas and liver, even when only implicating the stomach slightly, are accompanied by decreased acidity of the gastric contents.

In that form of malignant disease of the stomach which involves the walls of that organ either over the smaller or the greater curvatures, known to the French as cancer en cuirasse, the acidity is decreased, but HCl is not uncommonly present in the per stomach.

Cases.

1.

Cuttle, twenty three years old, female, rather anaemic, has a dull heavy pain in the Epigastrium continually and a sharp shooting pain which comes on immediately after taking food. Carbohydrates cause most pain. She vomited blood four months before and again two months before the date on which she was examined. She had never paid any attention to the colour of the stools.

The acidity of the contents of the stomach three and a half hours after tea was .456% as HCl. Free HCl present.

Diagnosis. Ulcer of the stomach.

Treatment, Stomach washed out, given Bismuth milk diet, small quantities frequently.

Result; Patient left hospital much benefited.

2.

Syme, oct. 26, female, has suffered from dyspepsia for 8 years. She vomited blood six years ago and again about six weeks since. Her stools were dark and tarry, she had pain in the epigastrium especially after food.

She still has melaena and great gastric pain. Acidity of stomach contents .36 %, free HCl present, four hours after food, tea and bread and butter.

In these two cases, which are types of a class, the acidity is high, — the hour after food, and after food with little nitrogenous material in it, being considered, — HCl is present in the free state, there are also, present, haematemesis, melaena and violent pain immediately after food.

6. Hepatic congestion simulating gastric ulcer

1.

Macaulay, twenty four, female, with a history of a bilious attack six months before. She was yellow and vomited blood and has never been well since.

When examined she had pain in the epigastrium which came on one hour at least after food

The acidity of the gastric contents was ·198% HCl, per HCl present, tested three and a half hours after food.

Diagnosis; Hepatic congestion.

Treatment; Washed out, chiefly for diagnostic purposes, calomel and bismuth.

Result; Great benefit.

2.

Beatrice Lumsden; æt. 35, female, complains of pain in the epigastrium, inability to eat, is very weak. Sent into hospital as a case of gastric ulcer. She has had smallpox and an attack of nephritis. Present illness commenced six months ago with severe pain in the epigastrium and the passage of tarry motions. Has pain on lying on her right side. Food does not increase the pain. Has not vomited either food or blood. Tongue is irritable. Liver enlarged, 2 inches below ribs, 1½ in below xiphisternum. Spleen slightly enlarged. Urine contains a trace of bile.

Acidity of stomach contents ·228%, trace of free HCl present.

Diagnosis; Hepatic congestion.

Treatment; Milk diet, stomach washed out, and for medicine nitro hydrochloric acid, strychnia and a cholagogue pill with scammony and Euonymin in it.

Result; Recovery.

3.

Mrs Lucas, forty years, a widow, complains of hæmatemesis. She has been much troubled with bile and used often to vomit. Lately she has had more frequent attacks, which came on at each monthly period. She then vomited dark stuff and her stools were black and tarry. The day before admission into Ward XXIX she vomited half a chamber full of clotted blood, and on admission a considerable quantity of fluid blood. Bowels loose and tarry. She has pain under the edge of the 9th right rib, under the angles of the scapulæ and at the tips of the shoulders.

Deep dulness of the liver 8½ inches, superficial 5½ in. Spleen is also a little enlarged.

Acidity of gastric contents ·18% HCl. per HCl present.

Diagnosis; Congestion of the liver, perhaps commencing cirrhosis (alcoholic.)

Treatment; Injection of morphia and atropine. milk and ice for a day or two, diagnostic washing of the stomach, then Chloride of Ammonium and Henry's solution.

Result; great and speedy improvement.

These three cases were sent into Hospital

as cases of Gastric ulcer and indeed the history and symptoms of each seemed to point to that affection. But on examining the Gastric juice it was found in each case that the acidity was within the mean of health. Appropriate treatment speedily brought about the desired result.

Many such cases are mistaken for cases of ulceration.

5. Types of anaemic cases

See p. 184 under cases of deficiency of free HCl, for one set of cases, a second set being comprised in those of the last section (no. 4. p.191)

The first class contain little or no free HCl and suffer from the Atonic variety of dyspepsia.

The Second class contain an excess of HCl and suffer from ulcers, & erosions.

6. Types of Dilated Stomachs.

These may be divided into the following classes

1. From fibrous contraction of pylorus, acidity high, free HCl present. Cf Bruce's case p. 178

2. From cancerous contraction of pylorus

with decreased acidity, absence of free HCl, the presence of blood and great fermentation of the case of S. A. p. 184

3. From over distension of the stomach with fluids, relaxation and consequent atony of the muscles. Acidity generally decreased, fermentations present. More common in Germany than in England or Scotland.

4. Acute dilatation of the stomach as mentioned by Hilton Fagge.

Cases

1. C. C. aged 14, male, had had an attack similar to the present one five years before. A year ago the present attack began, he vomited copiously one day then not again for several days. Sometimes the vomit was dark. Three months ago patient vomited some blood and passed some per anum. On admission patient was very thin and weak. His abdomen was greatly extended, especially in the epigastric and left hypochondriac regions. The Stomach reaches 2 inches below the umbilicus, over which area distinct splashing could be elicited. 80 ℥ of offensive fluid were drawn off containing sarcinae, .342 % acidity.

He went on well for some time but about a week after admission his liver dullness was noticed to be smaller, and he had twitchings of his hands

In the evening of the same day he was restless, hot but on passing the tube down the oesophagus it was caught by what was evidently a spasmodic stricture

Next day the patient was delirious, groaning. In the evening his face had an expression of horror. Early next morning he had cerebral breathing, cyanosis, irregular pupils and a high temperature. Post-mortem showed a dilated stomach, a small liver from simple atrophy, no bile in the urine or tyrosine. The pyloric orifice was narrowed due to an ulcer surrounding the opening, not of a malignant character. The other organs were sound.

2.

James Morrison, aet. 50, male, a drapers assistant, was admitted to Ward ~~XXIX~~ on Jan. 26 1889, complaining of constant nausea and pretty frequent vomiting; pain in the abdomen about the region of the umbilicus, and cramps in the hands and feet. He had been a very moderate drinker and had enjoyed very good health until three years ago when he had what was evidently a slight apoplectic seizure, he became suddenly ill and felt dizzy. He staggered but did not lose consciousness or fall. He remained well for six months after this, but then began to vomit after

very meal. About two years before admission he was so ill that he was admitted into the Infirmary under Doctor Muirhead. At that time there were Sarcinæ in the stomach wash. After a stay of seven weeks he was much better and went home again. Lately his legs have been swelling and he resolved to return to the Infirmary.

Condition: thin and flabby, temperature normal. He has a constant gnawing pain about the region of the umbilicus which, when bad, he relieves by sitting up and pressing his abdomen with his knees. This pain is worse half an hour after food. He occasionally vomits after his food usually a clear fluid, now & then with solids matter as well. He has never noticed any blood or coffee grounds. For the last year or so he has been in the habit of siphoning off the contents of his stomach every second night. Appetite fairly good, thirst excessive. Tongue coated with a white fur. His bowels are very costive. The abdomen is uniformly distended and the stomach comes down as far as 2 in. below the umbilicus, in which area splashing sounds can be elicited. Firm pressure over the pylorus, i.e. 1½ in to right of middle line and 2½ in above umbilicus, causes pain.

The other viscera in the abdominal cavity seem normal, the liver rather small.

On examination of the heart double mitral

and aortic murmurs were heard. Heart displaced somewhat to the right side.

The urine contained a trace of albumen at first but on the eighth day a deposit of silky crystals, which when shaken up in the urine gave it a watered silk appearance, occurred. These crystals were very similar to those described and figured in the case of Graham p. 182., and answered the tests for tyrosin. There were no Leucin balls.

There were deposits on the two following days of a similar character. After that with no deposit, the urine gave the tyrosin tests.

Fifteen days after admission he had some twitches in the right hand; a few hours after he had opisthotonos, dilated pupils, & rolling eyes. The muscles of his face twitched, the face had a kidney expression. He clenched his hands, puffed his cheeks out, ground his teeth, groaning all the while. Next morning he was comatose and died shortly after. His health was extremely good for the last 24 hours.

Diagnosis: dilated stomach from fibrous contraction of the pylorus, old endocarditis, kidney slightly cirrhotic.

Post mortem: on opening the abdomen the stomach was found to be of immense size. On filling it with water it held nearly two gallons and very

little of the water escaped, the opening through the pylorus being only pinhole in size. This was the result of great fibrous contraction. The liver was somewhat small, the pancreas large.

The Aortic and mitral valves were diseased.

The kidneys were cirrhotic.

There were two small and old hemorrhages in the brain just outside each lenticular nucleus.

The acidity of the stomach contents and of the urine were as follows.

Jan 27.

Four hours after tea.

Stomach contents .371% Free HCl present.

Urine .11%

Feb 2,

Stomach contents .288% Free HCl present.

Urine alkaline

Feb 3.

Stomach contents .252% Free HCl present

Urine alkaline, deposit of crystals in sheaves with tapering ends reacting like Tyrosin.

Feb. 6

Stomach contents .128% Free HCl present.

Urine alkaline, Tyrosin present.

(Was fed by rectum on this day and after.)

Feb 8

Stomach contents .044% No free HCl.

Feb 10th

Urine drawn off after death very faintly acid, urea 5·6 grs per oz, specific gravity 1017, trace of albumen present; gave the reactions for Leucine.

The acidity of the stomach contents fell each day towards the end, the sharpest fall taking place naturally after rectal alimentation had been begun.

The significance of the crystals is as obscure in this case as in the case of Graham.

When shaken up in the urine they formed a beautiful "watered silk" appearance, reflecting the light in changing forms; when quiescent they formed a white soft silky looking deposit at the foot of the glass. Leyden says that the mode of death, with coma and convulsions, together with a deficiency of urea in the urine with the presence of Leucine or Tyrosine or both, points to a condition analogous with or identical with uraemia.

This case then may have been one of acute Tyrosinuria and Tyrosinaemia to coin two words for the occasion, complicated with heart disease.

Cases have been put on record also in which patients with dilated stomachs have died with coma or convulsions. Can these have been similar cases to this one?

3.

The following case is similar in some respects to the last one, and I have to thank the resident in Ward XXII who was on duty during the autumn of 1889 for an abstract of the case.

Ellen Harrison, 27, married, complaining of pain in the stomach, faintness and hæmatemesis, admitted on Sept. 3. 1889. Gave a history of two attacks of pain followed by hæmatemesis.

On admission, she has pain at once after eating, pain also on pressure at the umbilicus. Stomach is dilated. Next morning after an attack of agonising pain vomited blood. In the evening I examined a specimen of vomit which had just been ejected. The acidity was considerable, .216 %, no free HCl present. Blood present. Numbers of Sarcinæ. She was fed during this period solely by the rectum. On Sept 19th there was a copious deposit of similar crystals to those found in the last case. Urea 10.5 grs per oz. Next day phosphates and a few of the supposed Tyrosine crystals were seen. The urine was always alkaline and before the deposit appeared was supposed to contain acetone from the curious reactions which it gave on testing. The crystals gradually disappeared and the patient recovered.

Other cases of dilated stomach and analyses of the stomach contents are included in the 1st division of these Types pp 178 et seq.

7. Cases of dyspepsia in young women not necessarily anaemic.

I have given this title to a class of cases commonly seen in women who often take little exercise, whose bowels are usually very costive and who suffer from very deficient appetite and complain of pain even after the little they do eat. I have met with it in men also but have no analyses in such cases.

1. L. S. 24, has suffered for long from a subacute dyspepsia. She otherwise is in very good health. She is not anaemic. Takes very little exercise. The pain is of a dull character, located in the epigastrium and is much worse after food especially after vegetables. Bowels very constipated.

Analysis of vomit, acidity deficient .108% 2 hours after dinner, only a trace of pepsin.

Urine very acid, loaded with urates.

Treatment; more exercise, more fluid, more proteid, less vegetables and bread. Ordered her to take

more salt with her food and after each meal 15 minims of dilute hydrochloric acid.

Result. Cure.

2. A. L. 28, female, somewhat stout, had influenza a three months before and has had dyspepsia since. Pain after eating, load in the stomach, loss of appetite, with vomiting now and then. She takes little exercise, but drinks a considerable quantity of water and milk. Bowels constipated, liver very slightly enlarged.

Analysis of Stomach contents vomited,

Acidity below normal ·126 %, trace of free HCl 3 hours after food. Trace of Lactic and Butyric acids.

Urine normal.

Treatment; chiefly a proteid diet, with light stocks with it. Careful regulation of the bowels. Fifteen minims of dilute Hydrochloric acid and 10 of dilute nitro hydrochloric acid made up with water and a small quantity of Saccharin after each meal. Regular exercise, this she took on horseback.

Result. Cure.

3. M. E. 25, female, stout, complaining of the same symptoms as the above two cases. Takes little exercise and drinks little fluid. Acidity below normal.

Treatment, more salt with food, dilute HCl after

meats, which were chiefly proteid for a time, and more exercise.

Result Rapid cure.

The above three cases are types of a very numerous class, and their symptoms may all be traced to deficient HCl. The causes of this deficiency are probably the small amount of proteid food eaten, the little amount of exercise and the constant constipation. May not another cause be the small amount of salt taken with the food?

These types of cases show the amounts of free, and combined HCl, and of the organic acids in various disorders.

I wish especially to accentuate the following points.

1. That the administration of alkalies for acidity has only a very brief effect on the stomach contents.

2. That the pain of HCl acidity is often assuaged by proteids.

3. That regular lavage of the stomach relieves in great part the symptoms of many of the chronic dyspepsias; and that this procedure if continued diminishes, sometimes without the administration of drugs, the

hyperacidity present (cf pp 179 etc).

4. That as has been often pointed out before, the acidity of the urine varies inversely with that of the stomach contents as a general rule.

Use of these conclusions will be made, when speaking of the modes of treatment.

Chapter II

The combined acidity more carefully examined.

Having convinced myself of the presence and reality of the combination of hydrochloric acid with proteids, I now proceeded to examine further into the matter, and the points I particularly directed my attention to, were, the amount of acidity each different albumenoid combined with, if it varied under varying conditions of heat, strength of acid, or not, the diffusibility of acid so combined and the power diffusion had on the stability of the compound, the power acid in this state had with regard to further digestion, and the effect of the presence of other acids on the combining power of HCl.

1.

Properties of hydrochloric acid organically combined with proteids.

If a certain quantity of a proteid soluble in water be dissolved in a known quantity of a titrated HCl aqueous solution, a certain amount of the acid combines with the proteid, if the amount of the proteid be small in proportion to the acid, only a part of the acid so combines, if, on the other hand, the proteid exceed in bulk the

acid all the acid combines. The total amount of acidity, the total value of it, that is to say, as estimated by pheno-phthalein and Caustic Potash, undergoes no change, or an extremely slight one. HCl, then, combined with a protid is still as strong an acid towards KaHO as it is when free.

Its nature, however, is changed in other directions, for, as I have shown, it has little or no digestive power, it cannot affect Phloro-glucin-vanillin, when dried with it, nor does it affect the Resorcin test, applied in a similar manner. If the combined acid be used, with no trace of free, Liebermann's reaction, the beautiful purple colour that appears on drying a protid with an excess of free HCl, is absent. If a solution of free HCl be evaporated with out protid material present, no acidity remains after dryness is reached, with protid present, however, an acidity proportionate to the protid is found on titration after drying and dissolving again in distilled water.

Free HCl discharges the colour of Uffelmann's Carbolo-ferric solution, combined HCl, on the other hand, changes the colour to a yellow, not so bright as the yellow given by Lactic, nor so dark, unless the strength be greater than is ever observed in the stomach, as Acetic acid.

Organically combined by deschloric acid, then,

must be some compound, some chemical unit even, in which a weak acid, like albumen or globulin is combined or united with a strong acid, or Hydrochloric acid. In nitro-hydrochloric acid two strong acids are combined and have different attributes to those of either of the single acids, in the combined hydrochloric acid, the (chlor-hydrique Organique of the French, the two acids are combined in a similar way perhaps, the resultant acid also having different characters, being however in this case very unstable.

a. Solubility.

The solubility of the combined hydrochloric acid varies with the solubility of the proteid involved.

HCl combined with peptone or albumose is soluble in water to the same degree that the individual substances are. But if some dried peptone with some combined HCl, or shorter some peptone-hydrochloric acid, be washed with absolute alcohol the peptone of course remains unchanged, but part and in time nearly all the acid may be removed, and removed in the free form. The same applies to albumose.

HCl however, combined with coagulated albumen or globulin, is, if washed with water when in the dry state, removable in part as the free acid, in part, a very small part, as acid-albumen, soluble in the acid given off into the water by the previous part.

the rest remaining with the albumen. Repeated washing however will remove all the acid. The acid behaves to alcohol as in the previous instance.

In this case the HCl does not only combine to form acid albumen, for if all the acid albumen formed be removed, the coagulated and insoluble proteid left still is combined to HCl.

If instead of using coagulated proteid, egg-albumen be used, HCl added and the mixture dried at 36° Cent. the acid remainder is nearly soluble in water, the proteid easily precipitated by alcohol and part of the acid removed by that fluid.

6. Diffusibility.

This point was one of the most important, with regard to the compound acid, that I had to settle.

I devised two sets of experiments to show the amount of diffusibility just without pepsine present, secondly in the presence of pepsine and while digestion was going on.

In the first chapter of this part I have already shown that when a solution of HCl dialyses through a membrane into a proteid solution, that solution becomes more acid, in time, than the fluid outside. On examining however the two fluids more carefully I found that all the combined acidity did not remain inside for if the proteid used was diffusible itself, as peptone or if pepsine were

present and digestion proceeding, proteid material soon appeared outside and with its appearance of course some combined acidity also; the proportion however of the proteid inside being usually greater than out, the acidity remained higher.

On the other hand, if a solution of ~~coagul~~ albumen, as egg albumen, and hydrochloric acid, none of which is free, be put inside a parchment tube, and distilled water be poured round it in a beaker, in time the water outside will contain some hydrochloric acid, and if the water be evaporated to small bulk, a trace of free HCl will be found. Some of the combined acid has come away as free, and, there being no proteid outside, has remained in this condition.

If again to this solution of albumen a small quantity of pepsine has been previously added, the proteid again not being oversaturated with acid, and the solution placed as before in a dialyser with distilled water round, the whole being kept at 40° centigrade, some but not much peptone with acid combined to it will be found outside, probably with no free acid.

Thirdly a solution of different proteids, with peptones amongst them, again not oversaturated with acid, may be placed in the tube, when combined peptone-hydrochloric acid soon appears outside.

In the first chapter of this part some of the earlier experiments show the diffusion out of acid combined to indiffusible proteids, if pure water be placed outside, I will now proceed to detail some experiments performed to show the course of the acidity combined to peptones and to consider that combined to albumoses.

Experiment 1.

A solution containing HCl combined to proteids, made by digesting fibrin with pepsine and HCl, adding an excess of fibrin, until no trace of free HCl was present, boiling and filtering, was used, which was of ·0684% HCl acidity
·0873% HCl Total Chlorides

10 ccs of this fluid was placed in a parchment tube, surrounded with water, for one hour at 36° Centigrade, then examined.

There were now 12·5 ccs of an acidity ·432%
Chlorides. ·4596%

Original acid.	·0684 gr.	Remaining	·054 gr.
Original Chlorine	·0873 gr.		·057 gr.
Original Proteid	·6275 gr.		·48437 gr.

The proteid was estimated by precipitation, from the fluid evaporated to a syrup, with absolute alcohol.

The alcohol used in precipitating the proteids in the second case was examined for its acidity and chlorides and it was found that of the original ·01728 gram. of acid in the part

used for the testing ·01512 gr appeared in the alcohol, and of the ·018382 gr of Chlorine, ·01626 gr appeared, indeed a very large proportion of the acid and chlorine originally present.

The result of this experiment shows that during only one hour there was a considerable loss both of proteid, here probably peptone, and of acid and that the loss was proportionate.

Experiment II

In this I paid more attention to the acids both inside and out.

I used a solution of peptones and albumoses in water, containing HCl both in the free and combined state.

Total acidity ·234%
Combined acidity ·198%
Free acidity ·036%.

50 ccs of this fluid was put in a dialyser and 200 ccs of distilled water round.

After 24 hours dialysis the figures were as follows

		Inside.	Outside,
Acidity,	Total	·072%	·0324%
	Combined	·072%	·0288%
	Free	0	·0036%

There were 58 ccs inside, and 185 ccs out.

The absolute amount of acid in grammes

was as follows;

Inside.	Total acidity.	Combined	Free.
Originally:	·1178 gr.	·0998 gr	·0180 gr.
afterwards			
Inside	·04176 gr	·04176 gr	0
Outside	·05994 gr	·0533 gr	·00664 gr
Together	·10170 gr	·09506 gr	·00664 gr.

A small proportion of the acid was lost in the estimation ·0163 gr, chiefly in the free acid, but the experiment shows the change in the distribution of the acid well, that which has gone outside being probably combined with peptones, which are evidently in this case in excess of the albumoses.

Experiment. III

Apparatus used, glass beaker, and parchment tube as before.

Inside ·882 grammes of dried fibrin +50 cc H_2O

Outside 177 ccs HCl solution, ·108 % or ·19116 gr HCl.

Pepsine was added and the whole kept at 40° Cent. for 24 hours, when there were 57 c.cs inside, 145 c.cs out.

Inside,	57 ccs,	·126 % acid	= ·07182 gr HCl.
Outside	145 ccs,	·09 % acid	= ·1305 gr HCl.
Together	202 ccs,		= ·20232 gr HCl.

The slight increase of acidity is due to the

acidity added with the pepsine, which is generally slightly acid, and to the fact that as a rule I added one or two drops of the decinormal KaHO solution, when I was titrating, over the necessary amount, in order to make certain that I had reached the true and certain point of change between acid and alkali.

The fluid outside gave the Biuret reaction, but contained no proteids coagulable by heat and acetic acid, nor on saturation with ammonium sulphate.

10 ccs of the fluid outside dried in a weighed capsule gave .031 gr of dry residue or .4495 gr altogether

10 ccs of the fluid inside dried in a weighed capsule gave .0756 gr or .4332 gr.

Total Solids recovered = .8827 gr.

The ash was so small in both cases as to be inappreciable.

The acidity inside consisted of .07182 gr HCl or .126 %, of this .0513 gr or .09 % was combined, .02052 gr or .036 % free.

The acidity outside was .13058 gr or .09 %, of this, .0522 gr or .036 % combined, and .07838 gr or .054 % free.

The total solids outside, chiefly peptones, were .4495 gr in weight, subtracting the combined chlorine from them = .3973 gr, the com-

-bined acidity itself ·0522 gr., the proportion of peptone to combined acidity being therefore 100 to 13·14.

5 ccs of the fluid inside were neutralised the precipitate filtered washed and weighed; after drying, = ·038 gr = ·76 % = ·3952 gr in 5·7 cc, of acid albumen.

5 ccs of the fluid were used to estimate the Serum albumen and globulin, = ·004 gr or ·08 % = in 5·7 cc, ·0456 gr, this was all globulin.

The total results of the experiment may be summarised thus;

Originally

Fibrin	Acid
·882 gr.	·1911 6 gr +

Finally

	Solids.	Acid.
Inside		
Acid albumen	·3952 gr	Combined ·0513 gr.
Serum globulin	·0456 gr	
Peptones + albumoses	·0216 gr.	
	·4624 gr.	Free ·02052 gr.
− Chlorides	= ·4332 gr.	·07182 gr.
Outside		
Peptones +		Combined ·0522 gr.
(combined Chlorine	·4495 gr	
− (comb. Chlor.	·3973 gr.	Free ·0783 gr.
	·3973 gr.	·1305 gr.
Grand Total	·8405 gr	·20232 gr.

This experiment corroborates the last, and it should be noted that the percentage of acid combined to proteid inside is 11·9 %, outside 13·14 %, while inside the proteids are chiefly acid albumen and globulin, outside peptone.

The peptones in this case have been formed inside and have dialysed out, causing the appearance of the combined acidity outside as well as in.

The loss in the total solids at the end of the experiment, must be put down to errors in working.

I repeated this experiment, using different quantities

Experiment. IV

Apparatus similar, temperature 40° Centigrade.

Inside; 1·333 dried fibrin, + a small quantity of dried pepsine and 50 ccs. distilled water.

Outside; 144 ccs HCl solution, ·216 % acidity
·218 % Chlorine.

Total Acid = ·31104 gr.

Total Chlorine = ·31392 gr.

After digestion for twenty four hours the fluids were analysed with the following results,

Inside 52 ccs.

Acidity ·243 % = ·12636 gr. HCl

Chlorine ·249 % = ·12792 gr. HCl.

Outside 120 cc.

Acidity ·165% = ·198 gr. HCl

Chlorine ·156% = ·1872 gr. HCl.

Of the acidity inside ·216% was combined, ·027% free, of that outside ·108% was combined, ·057% free, that is the combined acidity inside = ·11232 gr, outside ·1296 gr, or ·24192 gr. together.

The total solids were, inside ·832 gr.

outside ·658 gr.

1·490 gr.

Subtracting the combined Chlorine ·24192

1·24808 gr.

The total solids were made up as follows;

Inside

Undissolved	·26 gr.
Acid albumen	·13 gr.
Globulin	·13 gr.
Peptone & Albumose.	·2808 gr.
	·8008 gr.

Outside

Peptone & Salts	·444 gr.
	1·2448 gr.

Proportion of Total Solids to total combined acidity = 100 : 19·4.

In this experiment then it is clearly seen that there is combined acid outside as well as

inside, and that the presence of the combined acidity in greater proportion prevents the free acid becoming so great inside as out.

I used 10 ccs of the fluid obtained after the digestion to further test the diffusibility of the combined acid.

Experiment V

Dialyser as before.

Inside

10 cc Acidity ·243 % = ·0243 gr. HCl

Chlorine ·2496 % = ·0249 gr. HCl.

Outside

100 ccs, distilled water.

After twenty four hours,

Inside; 6·75 ccs

Acidity ·036 % = ·00244 gr.

Chlorine ·046 % = ·003105 gr.

Outside 88 ccs,

Acidity ·0216 % = ·019008 gr.

Chlorine ·02028 % = ·0178464 gr.

The Acid albumen originally was, in 52 c.cs ·13 gr, in 10 ccs = ·025 gr.

After diffusion, remained at ·025 gr.

That is that though the combined acid was diffusing out, for of the ·243 % acidity ·216 % was combined and the total acidity left is lower than that, the non diffusible proteids remained as before. The globulin also remained at the

same figure, as did presumably the albumoses.

Seeing that the action of diffusion had the power to dissociate the combined acidity, I wished to find out if the liberation of the acid in a free state from the proteid, could have any power of further digestion. Combined acidity, as I show elsewhere, is acid that has done its work and that cannot go further in digesting proteids, ~~without~~ Even with the presence of pepsine, than the state of the proteid indicates at the time. (as the small amount of acid liberated in a free state by diffusion, by its presence in a free state, further the action of digestion (in the presence of pepsine) on the proteids which are already saturated or almost saturated with acid?

Experiment. VI

I used a solution[x] of peptones and albumoses with .558% HCl acidity, containing no free HCl, as it was of .558% acidity after evaporation, gave no purple discoloration, nor a scarlet colour with Giungheys reagent.

1. 25 ccs of the above was put in a tube dialyser with 250 ccs of distilled water outside

2. 25 ccs were put in another tube, .086gr of dry pepsine added, 250 cc's of distilled water outside.

* This solution was the result of a previous digestion act-

Both were kept at a temperature of 100° Fahr. for four hours.

At that time the fluids outside were analysed

Outside

1. 241 ccs, ·0279% HCl, = ·067239 gs.
2. 237 ccs, ·02763% HCl, = ·066083 gs.

On evaporation of the fluids to dryness the following values were found;

	Dry residue. Peptones and Chlorine	Liebermann's Reaction.
1.	·229 gs.	Present.
2.	·432 gs.	absent.

Inside

1 26·5 ccs, ·252% HCl, = ·06678 gs.
2. 27·5 ccs, ·234% HCl, = ·06435 gs.

7 ccs of each used to estimate acidity, no free HCl in either.

Second Stage

1. 19·5 ccs of last, ·252% HCl, = ·04914 gs HCl.

Were put in a dialyser tube with 250 ccs pure distilled water

2. 20·5 ccs of No 2, of last stage, ·234% HCl = ·04797 gs HCl were similarly treated.

Dialysed for 24 hours.

Result.

Outside

1. 227·5 ccs ·018% HCl = ·04095 gs HCl
2 228· ccs ·018% HCl = ·041048 gs HCl

The fluids were evaporated as before, no Liebermann's reaction observed in either, the dry residue in 1. = .288 gr.

2. = .368 gr.

Inside

1. 26 ccs .045% HCl = .0117 gr.

2. 19.5 ccs .048% HCl = .00936 gr.

No free HCl in either case.

Third Stage

1. 21.5 ccs of No.1. from last stage, .045% HCl = .009675 gr HCl, in the tube, 250 ccs dist. water outside.

2. 15.5 ccs of No 2. from last stage, .048% HCl = .00744 gr HCl. in the tube, 250 ccs dist. water outside.

Dialysed for 24 hours at 100° Fahr.

Result;

Outside.

1. 220 ccs. .0036% = .00792 gr. HCl

2. 235 ccs. .0033% = .007755 gr. HCl.

all combined.

Solids after evaporation and drying

1. .041 gr.

2. .051 gr.

Inside.

1. 37 ccs .0036% = .001332 gr HCl

2. 7.75 ccs .0033% = .0002557 gr. HCl

The solids inside were then weighed, after drying. There was a distinct precipitate of heteroalbumose in no 1., very slight in no 2.

Albumose 1. ·29 gr.

2. ·015 gr.

To sum up then, of the proteids in the tube to which pepsine had been added only ·015 gr was recovered at the end, of those in the tube to which no pepsine was added ·29 gr was found.

The figures are;

	1. — Pepsine	2 + Pepsine.
Outside		
First Stage	·229	·432
Second Stage	·288	·368
Third Stage	·041	·051
Inside		
Third Stage	·29	·015
	·848	·866

That is to say then, that no. 2, with the pepsine, at the end of the experiment hardly contained any albumose.

The points that indicate the progress and difference of the two processes, are, first, the presence of free HCl outside in no 1, at the first stage due to more HCl diffusing out than the peptone which has also appeared outside can take up, in no. 2, on the other hand, no free HCl is present the amount of peptone

being sufficient to take it up. Both in stages 2 & 3 the amount of fluid inside the tube at the end of the twenty four hours is much less in the tube to which pepsine was originally added, showing that the proteid contents were less. The similarity between the acidity inside and outside in both cases, at the end of the third stage may be taken to indicate that the amount of acid present was so small that the action of diffusion had dissociated almost all of it, from the proteid allowing of its equal distribution.

I determined to repeat this experiment, slightly changing the details.

I shook up 25 ccs of white of egg with 75 ccs of water, added some pepsine and hydrochloric acid, and kept it at 38° Cent. Next day I filtered the resulting fluid and tested it.

The acidity was .164 % HCl.

Chlorine	.2166 %
Total Solids	1.81 %
Ash	.09 %
Organic Solids	1.92 %
Acid Albumen	0.
Albumen	.375 %
Albumose	.6 %
Peptone	.3184 %

No free HCl.

1. 40 ccs of such a fluid was put in a dialyser with 44 ccs of water, & a pinch of pepsine, with 200 ccs of distilled water outside.

Inside, then, there were ·724 grs Total Solids
·036 grs Ash.
·688 grs Organic Solids

2. 40 ccs of the same were boiled, and, with 44 ccs of distilled water but no pepsine, placed in a dialyser, with 200 ccs of distilled water round. The contents were therefore the same.

The whole was kept at 100° Fahr. for 24 hours.

Next day

Outside

1. 182 ccs; ·0175% HCl = ·03185 grs HCl
2. 183 ccs; ·0173% HCl = ·031659 grs HCl.

1. Total Solids ·2971 grs.
Ash ·0301 grs
Organic Solids ·2670 grs.
No Liebermann's reaction.

2. Total Solids ·2436 grs
Ash ·0328 grs
Organic Solids ·2108 grs.
A trace of discoloration on drying, probably therefore a trace of free HCl.
(Proportion of acid to Organic Solids minus the Chlorine 17·61%.)

Inside

1. 79.75 ccs .03075 % acidity = .02450715 gr HCl
2. 82 ccs .0351 % HCl = .02878215 gr HCl

No pepsin acid.

1. Total Solids .3828 gr
   Ash .01196 gr
   Organic Solids .37084 gr.
   Albumen .13706 gr .17 %.

2. Total Solids .4428 gr
   Ash .0082 gr
   Organic Solids .4346 gr.
   Albumen .1394 gr .17 %

Shortly then;

1. + Pepsine
   Inside .37084 gr Organic Solids
   Outside .267 gr " "
   Total .63784 gr " "

2. − Pepsine
   Inside .4346 gr Organic solids
   Outside .2108 gr " "
   Total .6454 gr " "

I found then that the addition of a small quantity of pepsine increased the amount of proteid material outside the tube, that is, in-

-creased the peptones, increased slightly, also the amount of acid outside, compared to the one to which no pepsine had been added, decreased the fluid inside, and increased of course the proportion of protid to acid outside, no trace of free HCl being observed, a small quantity of free acid having been noted in the other. It is note worthy that the albumen is only slightly if at all changed, the effect of the liberated acid probably being directed more towards changing the more highly saturated protid molecules into peptones, the different albumoses for example, than attacking the albumens.

In these experiments the contents of the dialysers had already undergone a preliminary peptic digestion so that presumably all the HCl that could combine had done so. That is to say that it had done as much digestive work as it was able to in a flask: But, with more pepsine added to make sure that there was no deficiency of that constituent, although indeed an excess had been added previously, and the fluid placed in a dialyser, further digestion went on, as was shown by the difference between the remainder in this tube and in the control. The control being exactly the same in all particulars save that it had been boiled. That the fact of boiling did not alter the circumstances is shown by the same quantity

of albumen remaining in both at the end of the experiment.

It is clear then that the small amount of free acid attracted by diffusion from the acid combined to proteids enables some further digestion to proceed provided pepsine be present. This occurred in the first tube, that with pepsine.

In the second tube this freeing of combined acid went on, but no pepsine being present it could not attack any further proteid material, but remained outside.

The combined acidity outside in No 1, after the experiment was over is greater than that in No 2, more peptones having been formed and dialysed. In No 2 of course the combined acidity dialysed through with the peptones, to which it had attached itself, these peptones having been originally present inside.

The following experiment was devised to show the difference in behaviour between acid (HCl) already combined to proteids before digestion, to that which has had all its affinities satisfied by a previous digestive act.

The preceding experiments have been performed with HCl with all its proteid affinities satisfied.

The following experiment is performed with HCl combined to proteids, but which had not yet attacked them with the aid of pepsine.

Experiment VIII

For this experiment I used four separate dialysers.

I used for the protid, white of eggs, prepared by shelling with sharp pieces of glass and then strained to remove the fibrous tissue.

18 ccs of the filtrate contained 2 gr of Protid.

I added, to a certain quantity of this, HCl solution in different proportions as follows:

1. Inside.

2 gr Protid. ·38528 gr HCl. 86 ccs in all or ·448% acidity

2.

1·98 gr. Protid ·24948 gr HCl 66 ccs in all or ·378% acidity.

3.

1·96 gr Protid ·08424 gr HCl 36 ccs in all or ·234% acidity

4.

1·96 gr Protid ·08424 gr HCl 36 ccs in all or ·234% acidity.

These were allowed to stand for three hours at 38° Centigrade, when the condition in which the HCl was in was tested. That is to say whether it was free or combined.

The methods used were as before, titrations before and after evaporation.

The presence or absence of Liebermann's reaction was noted.

(I should note that the fluid and preparation protein and acid which were used for determining these acidities have been deducted from the above tables. The figures given in that and in the succeeding tables of this experiment are absolute.)

Condition of the Hydrochloric acid in the above fluids

No.	Total acidity	Combined		Free		Liebermann
	%	%	HCl in gr.	%	HCl in gr.	
1	·448	·27	·2322	·178	·15308	+
2	·378	·252	·15448	·126	·0950	+
3	·234	·234	·08424	-	-	—
4	·234	·234	·08424	-	-	—

Percentages of Combined HCl to Proteid present.

	Total Proteid.	Combined acidity	Percentage
1	2 gr.	·2322 gr.	11·61 %
2	1·98 gr.	·15448 gr.	7·8 %
3	1·96 gr.	·08424 gr.	4·29 %
4	1·96 gr.	·08424 gr.	4·29 %

Outside the dialyser tubes, into which these four solutions were poured, 150 ccs of distilled water were placed.

·054 gr. of Pepsine was added to nos 2 and 3 respectively.

The four beakers with their contents were now placed in an incubator at from 38° to 40° Cent.

After six hours they were taken out, the contents both inside and out measured and analysed.

I will just give tables of the acidities observed.

1. Acidities after six hours in dialysers.

a. Inside

no.	Amount in ccs.	Total acidity %	Total acidity in grams.	Combined %	Combined in grams.	Free %	Free in grams.	Liebermann
1	91	·216	·19656	·198	·18018	·018	·01638	+
2	75	·2052	·1539	·2052	·1539	–	–	–
3	50	·126	·063	·126	·063	–	–	–
4	46	·144	·06624	·144	·06624	–	–	–

b. Outside

1	141	·108	·1522	·02119	·029884	·0368	·1224	+
2	130	·082	·1066	·07759	·10087	·00441	·00573	+
3	130	·0216	·02808	·0216	·02808	–	–	–
4	136	·0072	·009792	·002104	·002862	·00693	·00942	+

2. Proteids after six hours in dialysers

a. Inside.

No.	gms Albumen	gms Acid albumen	gms Albumose	Peptones & Extractives	Total Proteids.
1	0	1·85·64	Trace	·02073	1·87713
2	·12.	·245	·28	·8036	1·4486
3	·851	·42	·101	·29922	1·67122
4	1·0948	·7314	Trace	·04044	1·8666

b. Outside.

1	–	–	Trace	·12287	·12287
2	–	–	·076	·47514	·55514
3	–	–	·018	·291876	·309876
4	–	–	Trace	·0934	·0934

Total Proteids, or Organic Solids.

No	Inside	Outside	Together.
1	1·87713 gr	·12287 gr	2. gr
2	1·4486 gr	·55514 gr	1·99 gr
3	1·67122 gr	·309876 gr	1·981096 gr
4	1·8666 gr	·0934 gr	1·96 gr.

3. Total Solids and Ash Outside.

No.	Total Solids,	Ash.	Organic Solids.
1	·196698	·073814	·122884
2	·63	·0786	·5514
3	·38369	·073814	·309876
4	·1672	·0738	·0934.

4 Proportion of HCl outside to the organic Solids.

No.	HCl (combined)	Organic Solids.	Percentage.
1	·029888 gr.	·122884 gr.	24·3
2	·10087 gr.	·5514 gr.	18·2
3	·02808 gr.	·309876 gr.	9·06
4	·0028612 gr.	·0934 gr.	3·06.

This experiment is somewhat complicated, yet is easily understood.

I will now explain it seriation.

First it will be observed that in the two first of the series there was an excess of HCl present at the beginning, before the fluids were placed in the dialyser. That is to say that free HCl was present as well as the organically combined form. In the other two however all the HCl had combined with the albuminoids present.

Then ·054 gr of dry pepsine was added to nos 2 and 3.

In no 1 there was therefore a considerable quantity of free HCl and no pepsine. In no 2 there was a smaller quantity of free HCl available, pepsine also being present. In neither 3 or 4 was there any free HCl, but in no 3, some pepsine was present.

The hydrochloric acid it will be noticed had combined so far with the proteids present in the absence of pepsine, differing therefore from that in the last experiments.

After digestion for six hours the amounts of the different ingredients were calculated in the usual way. The amount of organic material, estimated by weighing a certain quantity of the fluid outside after drying at 110° (wt and after incineration, served as a basis to calculate the peptones and any other diffusible organic substances, which had come through the membrane.

It will be seen from the figures given in the preceding tables, that there was a considerable diversity in the four results obtained.

In no 1, all the albumen present had been changed into acid albumen, or had made its way through the wall of the tube.

It is a remarkable fact that the fluid outside gave a slight precipitate on saturating with Ammonium Sulphate, none on boiling with Acetic Acid

added, and none on saturation with NaCl. There was therefore a small — a very small quantity of Deutero albumose outside

[Is Deutero-albumose therefore diffusible to a greater degree than other albumoses?

For all proteids do diffuse slightly in time but those above deutero albumose do so only in infinitesimal quantities and after a long period of time.]

HCl was present in the free state both inside and outside

Result of No 1. originally albumen with excess of acid, finally acid albumen and a small quantity of diffusible organic material, probably albumose and peptone, with, as well, excess of acid.

In No 2, the process had gone further and, although there was a trace of free acid outside, none could be detected inside. All the varieties of proteid were present and an appreciable amount of the proteid outside was deutero-albumose.

It is noticeable that the free acidity available at the commencement of the experiment amounted to ·095 gr HCl, while at the end only ·0053 gr was obtainable.

Result of No 2. originally albumen with excess of HCl and some pepsine, finally all forms of proteid, and diminution of ·0897 gr in the amount of free HCl. In digestion therefore free HCl is used up, or rather combines further with proteids.

In no 4 to begin with there was no free HCl in the solution. No Pepsine was added, but after the dialysis a trace of free acid was found outside. There was none found inside at the end.

Result of no 4; originally albumen with an amount of acid added insufficient to saturate it, finally a certain quantity of acid albumen formed with a small amount of the lower proteids.

In no 3, however the quantity of pepsine added at the commencement to protid and acid, which were in exactly the same proportion as in the last, caused the production of a considerable quantity of the simpler proteids.

There was no free HCl either inside or out, i.e there were sufficient peptones outside to combine with all the free acid which might have dialysed through.

Result of no 3; the addition of pepsine to albumen and acid, all of which acid is combined to the proteid, causes a further digestion, the amount of peptone and albumose formed being of course dependent on the amount of acid present.

Remarks;

Contrasting the results obtained in nos 1 and 2 in this last experiment, it will be seen that the total diminution of free HCl at the conclusion of experiment is only ·0143 gr in no 1, ·0897 in no 2.

The ·0143 gr. HCl of no 1 had combined with a small quantity of proteid, in the absence of pepsine, to form albumoses and peptones, ·12287 gr. in amount. That is 8·3 gr. of acid to 100 of proteid. But a certain amount of acid had combined with the albumen before the fluid was put into a dialyser. The 8·3 % of HCl represents therefore the additional work and energy required to change the previously formed Acid albumen into simpler forms. (·12287 gr.).

The ·0897 gr. HCl of no 2, which formed the difference between the pre HCl before and after digestion, had transformed 1·615 gr. into simpler forms. That is 5·5 parts of HCl to 100 of proteid.

But it will be noticed that in no 2. a certain amount of unchanged albumen remained at the end. Now probably before digestion began all the albumen had not been changed into acid albumen as the amount of pre acid was less than in no 1. The acid then has probably not attacked the albumen showing a preference for combining with, or, to put it in another way, a greater acidity for, the simpler acid albumen. in the presence of pepsine.

Or, again, acid enabled by the pepsine to produce further changes in proteids, acts by preference and to begin with on the proteids already changed by the simple action of HCl.

This must be so, otherwise the energy of the pre acid which was used up during the digestion

process in No 2 would have attacked the unchanged albumen before producing further changes in the acid albumen.

From the fact that, in both Nos 3 and 4 digestion could go on without the presence of free HCl throughout the experiment, it follows that in cases of gastric cancer in which there is an absence of free HCl the same may occur. That is, the supply of acid is too small to saturate all the proteids present or conversely the amount of proteid material is more than sufficient to use up the free acid in such cases.

The action of HCl in acting preferably on the simpler albumens in the presence and with the aid of pepsine explains the occurrence in a very short space of time of the different proteids in the stomach. At the beginning of digestion the HCl, as secreted, first forms some acid albumen, this is changed, as a rule, into albumoses and peptones before further albumen molecules are attacked.

The addition of a very small quantity of free HCl and a little pepsine to a mixture of albumen and acid albumen which contains no free HCl results, not in more acid albumen, but in the formation of albumoses & peptones from it, the albumen remaining the same.

The conclusions I feel warranted in drawing from this part of the subject are.

I. That combined HCl may be separated into two classes;

1. That which is united to albumenoids without the presence of pepsine. It is still capable of digesting on the addition of the ferment.

2. That which is united to albuminoids in the presence of pepsine. It is no longer capable of digesting any further proteid material, until it has been separated from the albuminoid it has already combined with, either by the action of diffusion or by washing.

II. That a very small quantity of free HCl present can, in the presence of pepsine, change proteids, already almost saturated with acid, into simpler forms. That, also, this free acid can be obtained in sufficient quantity for this purpose from the acid combined to other molecules of proteid matter by the action of dialysis.

III. That the nature of the combined HCl is, in all probability, a combination of the acid to the proteids themselves.

IV. Another indication is given in these observations, that the simpler proteids combine, bulk for bulk, with more HCl than do the more complex forms.

Proportion of acid which combines with the different albumenoids.

This subject has been already investigated by ones or two observers.

Danilewski[46] was the first who tried to estimate the exact amount, coming to the conclusion that from 10 to 12 parts of HCl were taken up by 100 parts of proteid material.

Ewald[8] also came to much the same conclusion.

Hertt[169] working in Maly's laboratory found that the hemialbumoses took up HCl with avidity

Moritz[116] gives 8 to 12 parts of albuminates to one part of HCl or 12·5% to 8·3%.

Pfungen[121], working with the albumenoids as contained in the food, experimented first with pork beef rubbed down fine and found that a meal of 100 gr of this required ·843 gr HCl, to exactly arrive at the point where free acid appears testing with methyl violet, a very uncertain test however. 100 gr of roll needed ·674 gr HCl, 100 gr of milk required ·504 gr HCl, these researches are not to be relied on.

He however estimated the point where the free acid appeared in a few substances by means of Günzburgs reagent and these results are more

satisfactory ; they are as follows.

100 gr Serum albumen masks 8·4 gr HCl.
100 gr Egg albumen masks 19·05 gr HCl
100 gr Fibrin (dried at 110°C) 10·956 HCl.

Sansoni and Molinari[61] finally, have tried to work out the problem in the following manner, in a very interesting research. They added to a known quantity of a decinormal or a centinormal solution of HCl, a solution of an albuminoid until the fluid ceased to give a reaction with phloroglucin-vanillin, then calculated the amount of albuminoid used.

They experimented with egg albumen, serum albumen, peptone, fibrin, myosin, caseine and the serum of milk, all of them in the raw or unboiled state.

First using a solution of egg albumen (albumina d'uovo) of a strength of ·301 % with, in 100 gr of dried albumen, 1·9 gr of ash. they found that 5·cc of a $\frac{1}{10}$ N HCl solution was masked by 77 cc of the albuminous fluid or ·253 gr of albumen, = 7·1 %.

They mention however that egg albumen saturated with acid becomes ipso facto acid albumen, and is now not coagulated by heat, but precipitated by the addition of an alkali to neutralisation.

This fact I do not altogether coincide with.

Using a stronger solution of albumen, .6262% they find 7.2% of acid albumen combining.

They also used Sulphuric, Lactic and Butyric acids in these experiments and found that 10.5% H_2SO_4, 52% Lactic and 140% Butyric acid combined, the last figures are incomprehensible. They estimated the influence of proteids on Lactic and Butyric acids by means of Lupocrotin.

In estimating the combination with Serum albumen, they differentiated between the amount required when testing with phloroglucin-vanillin with methyl violet, lupocrotine or congo red; how they worked with the three latter is not stated.

They found then, that uncoagulated serum albumen combined with 8% HCl (Günzburg)
12.4% HCl (methyl violet)

Making use of a solution of peptones made from fibrin and containing 1.6% of ash the proportion of peptone to acid was as 100 to 3.6.

In the same way fibrin took up 8%
Casein 7.7%
Myosin 5.93%
Serum of milk 92.3% (?)

Summing up, besides the facts above noted, the authors say that the soluble albumens take up the acid quickly, the insoluble more slowly.

And that HCl combines very loosely with fibrin repeated washing with water removing most of the acid. (cf p 240) some remaining however.

All the results here noted must occur at once, the acid is added and the reaction tested immediately, I have no doubt that if the acid were allowed a longer time to act on the proteid more would combine. Secondly, any excess of free acid, as I shall show, causes more in proportion to combine Thirdly, the stronger the solution of acid (if there be some present free) the more the proteid takes up, a point missed in these researches. Fourthly, HCl does not seem to combine in such large quantities at the normal temperature as at that of the body. Fifthly, in testing the fluid constantly to see if the reaction be yet present a considerable amount of the fluid must be lost and a lower value arrived at.

My results do not tally with the foregoing, they are, as a rule, higher in proportion.

The method I employed, was that which I have employed throughout; that is, I added a known quantity of acid to a known quantity of proteid and set them aside at 36° (or 100°) cent. to evaporate. The remaining acidity was estimated, if there was a Liebermann's reaction it was noted and a drop tested with phloroglucin-Vanillin for free acid, this last was always neg-

-ative therapeut and need not be added to the dissociation notes, except in one instance cf p. 249

On turning back to part IV 1. of this essay it will be noted on p/p 125 that some of the values of the HCl combined to proteids are given. Again in part IV 2. p. 226 the percentage of acid to proteids is calculated as 17·61 %; the percentages of the earlier experiments being from 8·1 % to 17·5 %

To examine these more closely I just made use of egg albumen, procuring it pure by shaking up the white of eggs in a glass vessel and filtering with [illegible]

This contained 12·258 % of solid matter and 11·55 % of albumen.

Experiment I.

a. 3 ccs of the albumen solution used = ·3465 gr.
15 ccs of ·2304 % HCl solution added = ·03456 gr.
No free HCl present, with 9·98 % of acid, after solution had been warmed for some time.
1 cc of ·2304 % HCl solution added = ·002304
Free HCl present, with 10·6 % of acid.

b. Trace of pepsine added to foregoing and the whole placed in an incubator at 36° Cent. Next day the acidity was ·207 %, or, in the 18 ccs ·03726 gr HCl, no free acid with 10·6 % of acid to a 100 of proteid.

This experiment then shows that more HCl has been combined after the addition of a small quantity of pepsine and after digesting for 24 hours.

Experiment II.

I did this experiment also, by means of Güngburgs reagent and evaporation afterwards.

1 2ccs albumen = .23 gr. dried + 13ccs .18% HCl = .0234 gr.

2. 2ccs albumen = .23 gr. dry + 7ccs .342% HCl = .02394

3 2.ccs albumen = .23 gr. dry + 5.0cc .045% HCl = .02254 gr.

4. 5ccs albumen = .6975 gr. dry + 9ccs .342% HCl = .03078 gr.

The proportion and state of the acids was as follows

1. 10.17% Free HCl present (Güngburg)
2. 10.4% Free HCl present (Güngburg)
3. 9.98% Free HCl absent (Güngburg)
4. 5.34% Free HCl absent. (Güngburg)

∴ The combination of Hydrochloric acid and Eggs albumen seems to lie between 10.17% and 9.98%, in this case

Wishing however to see the result of heat, and different strengths of acids, I proceeded to the next experiment.

Experiment III.

Using the same solution of albumen I added to 1cc the following amounts of HCl, and Pepsine

1 15 cc HCl .162 %
2 7 cc HCl .612 %
3 10 cc HCl .126 %
4 15 cc HCl .162 % + pinch of pepsine
5 7 cc HCl .612 % + pinch of pepsine
6 10 cc HCl .126 % + pinch of pepsine.

Evaporated to dryness at 36° Cent.

	% of HCl available.	Acidity after Evaporation	Percentage Combined.
1	20.817 %	.0094 gr.	7.826
2	36.939 %	.0072 gr. ?	(6.26) ?
3	10.643 %	.0072 gr.	6.26
4	20.817 %	.01368 gr.	11.89
5	36.939 %	.02592 gr.	22.53
6	10.643 %	.01264 gr.	10.668.

This experiment then shows that the amount of acid absorbed by albumen varies with the strength of the acid and, more so, with the presence of pepsine, and consequent digestion.

There was obviously a mistake in no 2. some of the contents being spilt, but no 5, which has the greatest acidity after evaporation, shows how much more can combine, and even when pepsine be present in the others, if there be a large excess of acid present, more combines to the proteid.

The original percentage of acid available in No 3, is so small that, though Liebermann's reaction was present, only 6,·26% remained attached. In no 6, there was no Liebermann and all the acid available had combined.

The only explanation of this can be that the lower albumenoids can absorb, weight for weight, more HCl than the higher albumens, since during digestion more HCl combines.

Experiment IV.

This was done to corroborate the first part of the last experiment.

·1155 gr of albumin (1 cc. of solution) { + 10 ccs of strong HCl solution 1. ; + 5 cc of HCl ·846% 2. ; + 5 cc of HCl ·2304%. 3.

Evaporated at 36° (centigrade.

1. ·01332 gr HCl left = 11·52% Liebermann +
2. ·00681 gr HCl left = 8·99% Liebermann +
3. ·0054 gr HCl left = 4·76% Liebermann ±

In this case again the amount of acid combining with the albumen varies with the strength of the solution beforehand.

I next used for a similar set of experiments some crystalline globulin kindly given me for the purpose by D. Noël Paton.

This was a pure globulin, which, when dried over H_2SO_4, lost its crystalline character, drying in clear light yellow masses. These however became crystalline again on soaking with a dilute alkali.

Experiment I

I used .142 gr of this globulin adding 20 cc of .4392 % HCl solution (.08784 gr. HCl)

These were evaporated over night at 100° later next morning however, with a distinct Liebermann's coloration then was a trace of free acid remaining

The acid left = 19.738 %.

Experiment II.

a. .196 gr globulin + 10cc .3672 % HCl (18.73%)
Dried at 110° (ent. Liebermann + 6.6 ccs $\frac{N}{10}$ KOH solution used = .0234 gr HCl
= 12.9 %

b. .148 gr globulin + 10 ccs .4392 % HCl (29.67)
Dried at 36° (ent. Liebermann + 7.8 ccs $\frac{N}{10}$ KOH solution used = .02808 gr.
= 18.97 %

c. .199 gr globulin + 10cc .3672 % HCl (18.45%)
Dried at 36° (ent Liebermann — 5.9 ccs $\frac{N}{10}$ KOH solution used = .02034 gr.
= 10.22 %

Experiment III.

a. ·174 gr Globulin + ·017 gr pepsine

b. ·177 gr globulin

To each was added 50 ccs ·2% HCl. Solution added the capsules dried at 36° Cent for two days.

Then

a. Contents had been all dissolved i.e. digested, the dry residue of a dark brown colour.

10·3 ccs $\frac{N}{10}$ NaHO solution = ·03708 gr HCl

In ·174 gr globulin ·03708 gr HCl or 21·31 %

But from a similar experiment on a certain amount of dried pepsine and a ·2% HCl solution I found that 7·5% acidity remained.

Therefore subtracting from the total acidity left ·001275 gr. due to the ·017 gr pepsine, the true percentage of acid to proteid is

21·308725 %.

b. The contents here contained a considerable quantity of acid globulin and had a very beautiful purple colour.

8·ccs $\frac{N}{10}$ NaHO solution = ·0288 gr HCl

In ·177 gr globulin ·0288 gr HCl combined or

16·26 %

These experiments show the varying amount of acid combining with the same amount of globulin

under different circumstances.

The same amount, then, of the same proteid will combine with varying amounts of Hydrochloric acid provided the other factors are different. These factors are 1. Strength of acid solution used and more particularly the proportion between the acid present and the proteid.

2. Warmth under which the combination takes place.

3. Time; immediately on adding the acid you may get a smaller percentage than a little later.

4. Heat at which the fluid is evaporated at. That is to say that in specimens in which no peptone can be detected by Günzburg's reagent, the amount of combined acid left after evaporation at 100° Cent. is less than after evaporation at 38° Cent. Some combined acid then is driven off by a heat of 100° Cent.

Experiment IV.

In this I endeavoured to find out the exact amount of acid that combined with different forms of proteid under the same circumstances.

For this purpose I made a series of pure proteids beforehand.

Pure egg albumen I made by precipitating the

globulins in white of eggs by dilution with distilled water, filtering under pressure and drying the filtrate in shallow vessels at 38° Centigrade. The dry residue on pounding was a slightly yellow powder which contained a very small quantity of ash. ·02%.

The globulin used was some given me by Dr. Noël Paton. It was absolutely pure.

The acid albumen was made by the action of HCl on egg albumen, precipitating with soda, catching the filtrates on a filter paper, thoroughly washing with distilled water and drying over Sulphuric acid.

The albumoses were obtained by dialysis from some commercial "peptone", which in reality is largely albumose. The different varieties were separated out in the usual way.

The peptone was made from albumose by gastric digestion in a dialyser. The albumose being freed from salts by dialysis, the addition of HCl and a small quantity of pepsine allowed the peptones formed to transude into distilled water outside. The solution was evaporated down to small bulk, the peptones precipitated out with absolute alcohol and dried, they contained about 2 % of inorganic salts.

A solution of the above was effected in distilled water the amounts used being such that 5 ccs of the fluid contained ·01 gr of the protein.

To 5 ccs of these solutions ·0135 gr of HCl was

added.

The acid albumen of course did not dissolve until this acid had been added.

After the acid was added the fluids were evaporated in evaporating basins at 38° Cent and at 100° Cent. No pepsine was added.

The same experiment was repeated with .02961 gr of HCl present, also without pepsine.

While a fourth was carried through in the same way, the contents were evaporated at 100° Cent, but here .01 gr of pepsine was added to each.

The following table, the mean of several experiments, shows the amount of acid found to combine with each proteid.

Without Pepsine.	Evap. at 100° Cent .27% HCl.	Evap at 38° Cent .27% HCl.	Evap. at 38° Cent .5922% HCl
Albumen	7.2%	14.45%	14.4%
Globulin	8.6%	15.975%	18%
Acid albumen	9%	18.4%	19%
Proto-albumose	9.5%	23.6%	25.2%
Deutero-albumose	10.8%	27.9%	27%
Peptone.	16.2%	31.95%	28.8%

With pepsine, evap. at at 100° Cent. .27% HCl. (.0135 gr.)

Albumen	19.8%
Globulin	17.1%
Acid albumen	18.4%
Proto-albumose	18%
Deutero albumose	18%
Peptone	19.8%

It is seen at once that the amount of acid which combines with the different proteids rises progressively. The amount which combines with peptone indeed is as nearly as possible double that which combines with albumin.

The high values of the second row of figures is explained by the fact that all the free HCl had not been driven off, they had not been evaporated for a long enough time.

The high values of the third row of figures shows that with excess of HCl to begin with more acid combines.

The values of the fourth column, that after digestion with pepsine, are also very instructive. They are practically all alike. The digestive process in the presence of sufficient pepsine has converted them proteids into peptones and the present in ate acidity therefore combines with them.

The acidity combining with peptones in the first column is 16·2 %, the acidity in this from 17·1 to 19·8 %, the addition of pepsine has raised the percentage of acid combining, probably through its own power of combining with HCl.

I repeated the experiment with pepsine added, evaporating at 100° Cent. the values were as follows,

Albumin	18·8 %	Proto-albumose	19·8 %
Globulin	19·8 %	Deutero-albumose	20·2 %
Acid albumin	18·8 %	Peptone	21· %

The result of the previous experiments is then confirmed.

It should be noted here, that in combining HCl to peptones or albumoses without pepsine, these proteids take up the acid without changing their form. They have already been created from a more complex body by the action of digestion, the acid which then combined with them has been removed, in this experiment without pepsine it is replaced, probably replacing water molecules.

This matter is more fully discussed on p. 389

Again, Is it possible to have a combination of HCl with albumen or globulin without the formation of acid albumen?

I think it is, and for this reason. I do not believe albumen is formed into acid albumen until a certain quantity of acid has combined with the albumen molecule. Some can combine with it and that point may not be reached.

So if you add a solution of HCl to albumen and at once evaporate at 100° C., whether the albumen be coagulated before, or not, it soon is brought to that form by the heat, still on drying some acidity is kept. The proteid however is not in the form of acid albumen as it does not dissolve in an acid solution to any extent. HCl then combines to a certain extent with albumen or globulin without changing it into an acid albumen or globulin.

A few notes on this subject of the acid albumen will be found on p 262.

I will now add all the other observations I made with regard to the combination of acid to the lower albumens or proteids.

1. Hetero-albumose.

Some hetero-albumose was separated by dialysis from a quantity of Commercial peptone, by precipitation with ammonium sulphate first and then as stated by dialysis. It was insoluble in distilled water, even when heated and did not diffuse. It contained 2·941 % of ash.

I. ·0199 gr of this was mixed with 5 ccs of an HCl solution of ·522 % strength. After mixing free HCl was found to be present.

This was evaporated to dryness at 100° Cent. The acidity left was = ·00288 gr HCl

That is ·00288 gr HCl with ·01844121 gr of Hetero albumose, if the ash be subtracted or

15·6 %

II. ·0205 gr was then taken and 5 ccs of a ·04 % Solution of HCl added, no free HCl was present on testing.

·0205 gr of Hetero albumose minus the ash equal ·0199 gr.

The amount of HCl added equals ·00206 gr.

So that ·0199 gr of the albumose had absorbed the whole of the ·00205 gr HCl added, as there was no free HCl present.

That is Heteroalbumose can combine with more than 10·3% HCl.

III. 10 cc more of the ·041 HCl solution were added to the last. That is ·00615 gr to the ·0199 gr of albumose, or 30·9% (circa), free HCl was now present.

This was now evaporated at 100° Cent. and then titrated. After evaporation Liebermann's reaction was present, but no free HCl.

·00324 gr of acid remained or with ·0199 gr of Heteroalbumose.

16·2%.

IV.

15 ccs of a ·072% HCl solution were added to ·05 gr of Heteroalbumose, free HCl was present in the mixture, which was evaporated at 100° Cent. Available acid, 22%.

Acidity after evaporation = ·0081 gr.

or in ·0485 gr of albumose

16·7%.

V.

·024 gr of the albumose + 5 ccs ·45% HCl

Available acid 10·3%. Evaporated at 100°.

After evaporation ·0039 gr. HCl remained

That is with ·0232 gr. of albumose ·0039 gr. HCl combined

or 16·7%

The results of these experiments is to show that the percentage of acid combining with Hetero albumose, without the addition of pepsine, is very uniform, 15·6% to 16·7%

2.

Proto and deutero albumose.

These were formed in a similar manner to the Hetero-albumose.

I.

·176 gr. of these albumoses was dissolved in 20 ccs of a ·738% HCl solution and then dried at 100° Cent. ·02844 gr. of acid was left or 16·1%

II.

·3474 gr. was dissolved in 20 ccs of a ·126% HCl solution, and dried at 100° Cent.

17·2% of acid remained

III.

·0819 gr of the albumoses was used, 20 ccs of a ·36 % HCl solution and some pepsine added.

After evaporation acid remaining with proteid was 19·3 %.

IV ·351 gr of the albumoses was used, 20 ccs of a ·126 % HCl solution, some pepsine added.

After evaporation the acid remaining was 18·9 %.

The values, then, of the acid combining with Poulton and Dunlop albumose, when mixed, varies in this series from 16·1 % to 17·2 % without pepsine, from 18·9 % to 19·3 % on the addition of pepsine.

3.

Peptones.

Some peptone was produced almost pure by the peptic digestion of albumoses in a dialyser, the proteid outside was precipitated with alcohol and tested.

·3474 gr were dissolved in 60 ccs of a ·126 % HCl solution, on evaporation of 5 ccs of this the remaining acidity was 20·1 %.

II.

In the experiment on page ___ on the digestion of albumose the percentages of acid to peptone outside the dialyser on the two occasions were

1 20·066 %

2. 24·51 %

III

·0261 gr. of the pepsine from the second observation noted above was dried with an excess of stiong HCl. On evaporation ·006012 gr. HCl was left or

23·034 %

These figures then for peptones vary from 20 % to 23 %, and elsewhere through this essay, in fact wherever the combined acid and the proteids outside a dialyser have been calculated, these proportions will be found to exist.

We may consider then that it is proved from these observations that there is a progressive percentage of HCl combining with the different proteids, this percentage rising as the proteids become simpler.

In this way Free HCl diminishes during the digestion of proteids.

The percentages are as follows:

HCl to albumen	7·2 %	or 11 %
HCl to acid albumen	9 %	or 13 %
HCl to Hetero-albumose	13 %	or 16 %
HCl to Proto albumose	16 %	or 17 %
HCl to Deutero albumose	17 %	or 18 %
HCl to Peptone.	17 %	or 23 %.

These numbers are only approximate, and seem to vary with circumstances.

Acid albumen now requires a word.

If on adding HCl to egg albumen a quantity of this substance be formed it can be precipitated by neutralisation with an alkali.

If this neutralisation, however, be carried out carefully by means of phenol-phthalein and a decinormal solution of soda, it will be found that before the fluid becomes the slightest degree of a pink shade all the acid albumin will have been precipitated, and will have been almost all dissolved again.

In the same way if an acid globulin in solution be so treated, the precipitate which falls on addition of the soda is at its densest some time before the actual neutral point be reached. It however does not clear up so readily as the acid albumen, the solution having to become decidedly alkaline for this to happen.

There is some slight difference between acid albumen and acid globulin.

If there is any correspondence between the amount of acid albumin and the point of acidity at which it falls some more light might be shed on the amount of acid combined with it.

In testing the acidity of a solution with phenol-phthalein, — the same applies to cochineal, — the point at which the pink colour appears is looked on as just the neutral point.

If acid albumin falls before this point is reached, it falls while the fluid is still acid.

It was not difficult then to find if there was any constant ratio between the precipitation, the amount precipitated and the acid left still left.

The Soda added at first neutralised the free acid, then turned its attention to that combined with the proteid. As it displaced this, the proteid was precipitated, as however it took all the places left by the acid molecules the proteid how can alkaline albumen dissolved again.

The first experiment bearing on this point is the following.

Experiment. I.

20 ccs of a .07% solution of acid albumen was taken, dissolved in a .1122% HCl.

A decinormal solution of NaHO was added until the acid albumen was all precipitated. The amount added was 4.5 ccs, equal to .081% HCl, leaving .0312% still in the fluid. The phenol phthalein present was not coloured.

12.25 ccs of this fluid, or exactly half, after the addition of the Soda, were filtered, The other half was neutralised. The filtrate of the first was then titrated and the acid albumen on the filter paper dried and weighted.

The acid albumen recovered weighed .007 gr.

The filtrate required .55 ccs more $\frac{N}{10}$ NaHO for neutralisation, = .00198 grs HCl.

The second half unfiltered required .7 ccs NaHO $\frac{N}{10}$ for neutralisation = .00252 grs HCl

That is to say that the withdrawal of .007 grs of acid albumen included the withdrawal of .00054 grs HCl., or acid is to proteid as 7.7 %.

The filter paper had been washed with distilled water twice before the filtrate was tested. After drying and removing the proteid from the paper no acid could be extracted from the paper, so that it must have been with the proteid.

Experiment II

In the experiment on artificial digestion noted in detail above on p.117. I made an observation on each occasion in which I precipitated the acid albumen.

There was no acid albumen present at the half hour or at the hour and a half, at least not sufficient to weigh. At the hour, 2, 3 and 4 hours, however, the amounts of the proteid were .16 % .5 % .64 % & .52 % respectively. The corresponding acidities were .054 %, 144 % .216 % & .252 %.

On neutralising 5 ccs of the fluids with

decinormal katto solution and noting how much was required for total precipitation, the difference between the amount of Soda solution required for precipitation and for neutralisation could be obtained. After precipitation and filtration a drop or two more of the Soda solution was added in case too little had been added previously.

The figures are as follows.

Total Acidity in grams of HCl. in 100 ccs.	Acidity of which Acid albumen left in HCl (grams)	Acid left behind with the proteid left in HCl (grams).
·054	·0432	·0108
·144	·1152	·0288
·216	·1728	·0432
·252	·2016	·0504.

The Acid albumen as noted above had therefore the following relation to the acid, which remained in solution or was attached to it, after its precipitation.

Acid albumen grs in 100 ccs.	Acid, HCl grs in 100 ccs.	Proportion of HCl to 100 parts of Acid. albumen.
·16 grs	·0108 grs	6·75
·5 grs	·0288 grs	5·76
·64 grs	·0432 grs	6·75
·52 grs.	·0504 grs	9·69.

The proportions therefore vary considerably from 5·76 to 9·69 %. but it must be remembered that I was working with very small quantities. In the first case for example the actual difference in grams between the two titrations only amounted to ·000108 gr in one cc or ·0054 in 5 ccs.

Judging from the last three observations the increased acidity seems to cause a higher proportion.

It will be observed that curiously enough the actual difference between the two acidities is exactly $\frac{1}{6}^{th}$ of the total acidity in each of the cases.

From these experiments then it is seen that acid albumen falls before the acid solution in which it is dissolved is neutral. And that, although as yet the experiments do not afford a constant ratio between the precipitant and the acidity at which it falls, the strength of the total acidity of the fluid seems to have some influence in this direction.

I determined to investigate the matter further and performed the following experiment.

Experiment. III

I placed 1 gr of dried but not coagulated egg albumen, with 50 ccs of distilled water

in a dialyser, with 200 ccs of a ·072% HCl solution outside. Placed at 38° Centigrade.

Next day the contents were as follows.

Inside 5·3 ccs.

Total Acidity ·1116%

Combined Acidity ·072%

Free Acidity ·0396%.

Undissolved ·02 gr.

Proteids dissolved ·92 gr

Acid albumen ·565 gr

Outside. 182·25 ccs.

Total Acidity ·0504%.

---

46 ccms of the fluid from inside was taken in which there was ·49 gr acid albumen, and which had an acidity of ·1116%.

Decinormal soda solution was added with the following result,

Ccms of Soda added,	Result.
10·1 ccs. (·0363 gr NaO)	Precipitate beginning to fall.
13·3 ccs (·04455 gr)	Precipitate dense.
13·5 ccs (·048 gr)	Clearing up.
14·3 ccs. (·05148 gr)	Clear, alkaline.

That is to say then that the acid albumen began to fall when the acidity was still ·0603%

·0513 %. having been neutralised, that it all was precipitated when ·04458 gr of acid had been neutralised, leaving ·0147 % in the fluid. It now began to redissolve and it had nearly completely done so when the alkaline point was reached, that is at ·1116 %.

The total acid present was ·05148 gr, the proteid began to precipitate when ·01512 gr HCl was still present. Therefore that amount of acid was required to keep it in solution.

The combined acidity has already been stated to have been ·072 %. The acid albumen then began to precipitate very shortly after all the combined acid had been separated from the pro by neutralisation, for presumably the free acid is attacked by the Soda first.

The proportion of acidity left, (from the beginning of the precipitation,) in the fluid to the proteid is only 3·08 %.

Experiment IV

A very similar experiment with a pure globulin treated with HCl in a dialyzer. The resulting fluid was of ·0562 % HCl.

43·5 ccs were taken containing ·5 gr of acid globulin and ·02446 gr HCl.

On titrating the following result was obtained.

$\frac{N}{10}$ NaHO in ccms.	Corresponding HCl in grms	Results.
3·8 ccs.	·01368 gr.	First precipitate
5·4 ccs	·01944 gr.	dense precipitate.
6·8 ccs	·02446 gr.	Alkaline, pink, but precipitate has not cleared up.
7·9	·02844	Cleared up, light red.

That is to say that with ·5 gr. acid Globulin
The precipitate was clearing up when there had been added Soda = ·02446 gr. HCl.
The precipitate began to fall when ·01368 gr. HCl had been neutralised

·01078 gr. HCl

Or 2·15 % of acid to acid globulin.

Experiments V & VI

Two more corroborative observations were made with regard to acid albumen.

In No 1 there were ·251 gr. of acid albumen dissolved in a solution of HCl, per HCl being present. In No 2 there were ·296 gr.

In the first decinormal Soda solution was added until precipitation and alkalinity, in the second centinormal soda solution.

1	2	
No of ccs added $\frac{N}{10}$ Natho	No of ccs added $\frac{N}{100}$ Natho.	Result.
15·	251·6	Opalescence.
15·7	261·7	Opaque
16·4	271·6	Flaky precipitate
16·7	276·5	beginning to clear
17·4	287·7	clearing
18·4	290·6	alkaline, almost clear

The corresponding amounts of acid represented by the Soda solution are as follows.

1.	2
·0544 gr.	·090576 gr.
·05652 gr.	·094212 gr.
·05904 gr.	·097776 gr.
·06012 gr.	·09954 gr.
·06282 gr.	·103572 gr.
·06624 gr.	·104686 gr.

While the percentages as compared between the amount of acid albumen involved and the differences between the successive quantities of acid noted above are also noted below. The greater amount of soda used in No 2; and of course the corresponding increase in acidity neutralised, merely indicates that the acidity of No 2 was greater originally than that of No 1. It is the differences between the No amount of soda used to bring

about the first opalescence and the succeeding amounts necessary to bring about the other changes in the form of the acid albumen, that is to say, in its solubility, which concern us here.

Table showing:

I. Amount of HCl in grammes neutralised between the first opalescence and opaqueness in	1. ·00252 gr. 2 ·00363 gr	Percentage to acid albumen I 1·003% II 1·23%
II between opalescence and precipitation in large flakes	1. ·00504 gr 2 ·0072 gr	I 2·006% II 2·44%
III between opalescence and the first clearing	1. ·00612 gr 2 ·00896 gr	I 2·43% II 3·04%
IV between opalescence and decided clearing	1. ·00882 gr 2 ·012996 gr	I 3·51% II 4·42%
V. between opalescence and alkalinity	1. ·01224 gr 2. ·01411 gr	I 4·91% II 4·79%

These figures show a very close approximation and are therefore presumably correct.

A certain amount of acid then is necessary to keep this albuminoid in solution and it is precipitated in direct proportion to the amount of alkali added.

From the fact that, that it is nearly all dissolved up again before the fluid showed any alkalinity with phenol-phthalein, it is plain that the alkali added must change it partly

into alkali-albumen and even have power to dissolve it again, before that point is gained at which phenol-phthalein becomes coloured.

Cochineal is affected in the same way.

But that the fluid is not really alkaline or neutral when the acid albumen comes down in flakes is proved by the following observation in regard to No 2 above. After the fluid had been made alkaline, it was acidified again and the acid albumen again precipitated in flakes. It was now filtered and the filtered paper washed with distilled water several times. The filtrate, which contained no albuminoids, was acid and contained ·00216 gr. HCl.

The difference between the acidity present when the precipitate fell in flakes at first, and the alkaline point was ·00691 gr. HCl. That is to say that the removal of the acid albumen has caused the acidity to be diminished by ·00475 gr. HCl. This either represents acid attached to the proteid, or the amount of Soda (equivalent) necessary to be taken up by the albuminoid before the phenol-phthalein is changed by free alkali.

Does an alkali combine to proteids in the same manner as acids?

Influence of the presence of other acids on the combining power of Hydrochloric acid.

Wishing to find out whether the presence of other acids had any influence on the amount of HCl that combines with proteids I performed a a few experiments. The subject is of some practical importance for, as the combination of HCl to proteids is evidently the first stage of their digestion, if this combination is prevented by the presence of other acids then digestion must be delayed.

On reference to Mohnaric's work an abstract of which is given on page 242 it will be seen that he attributes some combining power to the organic acids.

An interesting query arises, does every acid, which can peptonise proteids combine in a similar manner to HCl, with those proteids?

Thorner [157] has investigated the peptonising power of many of the acids and he groups them thus. 1. HCl, this is the chief peptoniser among the acids.

Then in order of digestive power come 2. Sulphuric, 3. Acetic, 4. Oxalic, 5. Tartaric, 6. Citric, 7. Lactic, 8. hydrosulphuric acids.

Nitric acid has no digestive power at all.

I first wished to ascertain the action of an excess of acetic on previously combined hydrochloric acid.

Experiment I.

A solution of protid combined with HCl, no free HCl being present, was used with an acidity of .156 %, (Chlorine .156 % HCl.

10 ccs of the above was taken, an excess of acetic acid added, and the fluid evaporated in an evaporating basin at 100° Cent.

The acidity of this was, when tested after dryness had been reached, .456 % HCl, the Chlorine however was not diminished, i.e. it was still .156 % HCl.

The increase of acidity not due to HCl was therefore .300 %.

That is to say then that Acetic acid also combines with protid material, but, at the same time does not drive out any of the HCl already combined.

Experiment II

In this some coagulated protid from an effusion into a pleural cavity was used.

1. This was a control in which .098 gr of the protid was digested with 25 cc .126 % HCl solution and some pepsine.

The acidity after digestion was .072 % with .0936 % of chlorides, on evaporation at 100° Cent.

2. ·1378 gr of the coagulated proteid was mixed with 25 ccs of water containing ·126% of HCl and ·4% acetic acid; a pinch of pepsine was added.

After digestion and evaporation the acidity remaining was ·09%, but the chlorides were only ·0468%.

That is to say that the presence of acetic acid prevented so much of the HCl from combining with the albuminoids.

Experiment III.

·59 gr of fibrin, which when dry equalled ·1657 gr was put in 20 ccs of HCl solution ·126%, a pinch of pepsine added and excess of acetic acid. No digestion occurred.

Excess of acetic acid destroys the action of Pepsine.

Experiment IV.

·2397 gr of dried fibrin, with a pinch of pepsine, was digested with 20 ccs of HCl ·126% and 1·5 ccs of HNO_3 1·08% (as HCl).

This was kept in an incubator for five hours.

On analysis the fluid was found to be of ~~·207~~ ·188% acidity, but on evaporation

only ·342 % remained of which ·1248 % was chlorine.

The fibrin was all dissolved or in debris.

Result; a very considerable excess of hitric acid does not prevent digestin going on, if HCl be present as well.

In this case 14% of chlorine combined rather below the normal as shown on page 253.

Experiment V.

To clear up the point in the last experiment which was not clear, i.e. Does HNO_3 combine with peptids? I performed an experiment with it alone.

For this I used a dialyser in which I placed 100 ccs of milk with some pepsine. Outside were 184 ccs of hitric acid ·538% (calculated as HCl) acidity.

The dialyser with its contents was placed in a beaker containing the acid and kept at 100° Cent.

Next day, there was 109 ccs inside with an acidity of ·486%, on evaporation at 100° Cent ·324% acidity was left, i.e. ·162% was free. The milk was firmly coagulated and there was only a trace of peptone with the biuret reaction.

Outside 165 ccs with an acidity of ·258%, no peptone; lactose present.

Result, Nitric acid undoubtedly has some

power of combining with proteids, but has little or no power of converting albumens into peptones.

Probably a very small quantity of albumose was formed inside, this would give the Biuret reaction.

Under such circumstances Nitro hydrochloric acid would rather impede digestion, if given after food, unless some pure Hydrochloric acid be given as well. For the Nitric acid, attaching itself to proteids, would prevent the hydrochloric acid doing so to some extent, and thereby delay digestion.

It is a curious circumstance that HCl should be able after combination to convert a complex molecule into a simpler one, while HNO_3, although combining also, has almost no power of conversion.

The action of combined acidity on the activity of the salivary ferments.

Hydrochloric acid is known to check the action of the salivary ferments, but not until sufficient has been added to make the secretion decidedly acid. When the food passes down into the stomach mixed with the saliva it has usually an alkaline reaction, unless acids have been taken in with the food. Not long ago physiologists have taught that once having arrived in the gastric cavity the amylolytic process set up by the ferments go went on, unchecked by the natural secretion of the stomach, for a considerable time. That, in fact, the stomach seemed to give the saliva a start, as in a race, before seriously devoting its energies to the manufacture of acid and thereby to the neutralising of the properties of the ferments.

The amylolytic stage of gastric digestion, in fact, during which hydrochloric acid was not secreted. Ewald mentions this stage and remarks that it is in it that lactic acid is formed, probably from the food as others have pointed out. Indeed at one time the lactic acid was supposed to have been secreted by the stomach.

What all previous observers missed was the fact that though no free HCl was present during this stage the total acidity as shown by phenolphthalein is constantly rising and rising from

the beginning, from the moment that the food and saliva just enter the stomach, as pointed out by Hayem and Winter and by myself in the last chapter.

As I point out, with a heavy meal free HCl may not appear until after an hour, though usually with a lighter diet in three quarters of an hour, but all the time the acidity is rising.

What action has this HCl so combined to the food on the Salivary ferments?

Now Chittenden and Ely[43] found, contrary to the accepted ideas of physiologists that saliva had a more powerful action on starch, if it were mixed beforehand with an equal quantity of .05% HCl, although .05% HCl when pure inhibits the action. This seeming paradox is explained doubtless by the fact that the saliva usually contains a considerable amount of proteid material, and the pepsine, which I should have noted was added with the HCl, (an artificial gastric juice in fact,) also is of a proteid nature and combines like other proteids with HCl.

Some part then of the .05% HCl would combine with these proteids and thus render it less active, less active that is to say against the ferments.

If pure salivary ferment be added to .05% HCl, its action is inhibited.

Again Chittenden and Griswold[44] state that .005% of pure HCl increases the action of the saliva.

(h. Richet that Saliva + .2% HCl works better than saliva alone, probably however he has taken here a large amount of saliva and a small proportion of acid.

Astachewsky[31], again, declares that saliva is more powerful when acid.

Schmidt-Mulheim[144] states that peptones increase the action of the salivary ferments (by peptones are meant albumoses and peptones) and Seegen found from an analogous research, he mixed aqueous solutions of peptones over fresh liver, that more sugar was formed in that again. 1 to 2% peptones gave 4% increase. The acidity with the peptones was slight and did not make the saliva acid. Again, Schmidt Mulheim says that if peptones be used in an acid medium and added to the saliva more sugar is formed than if the same amount of acid were added.

The inorganic salts of the peptones play an unimportant part.

Langley[95] working at this subject gives the following figures.

Ptyalin is destroyed by solutions of HCl above .005%
Pepsine is destroyed by solutions of $NaCl_3$ above .5%
Rennet ferment is destroyed by solutions of $NaCl_3$ above 1.%

Again Langley and Ewes[97] in a paper "On certain conditions which influence the amylolytic action of Saliva" found that .0015% distinctly

diminishes the action, and ascribe the lessened action of the acid in some cases to the presence of proteids, the influence of which, they say, may be got rid of by dilution.

Langley and Eves got best results from Saliva absolutely neutral.

This last observation is probably the correct one, the addition of small quantities of HCl serving to make the saliva neutral, the amount required varying with the alkalinity of the saliva at the time.

With a view of estimating the action of combined HCl on the ferments, and comparing it with that of the free acid I performed the following experiment.

Experiment I

I made some starch paste with warm water, of a strength of 1·5 %.

I collected about 15 ccs of my own saliva and filtered it. The alkalinity was not tested.

I also made some combined HCl, by adding to a certain quantity of proteid material some hydrochloric acid and pepsine, adding again more proteid until there was no reaction for free HCl in the contents. This finally had an acidity of ·504 % all combined.

7 flasks were used and during the experiment were kept at 38° Centigrade.

The details are as follows.

Flask				
1	5ccs Starch	+ 1cc Saliva	+ 2cc Hll	·504% Comb.
2	5 " "	+ 1 " "	+ 2 " "	·252% comb
3	5 " "	+ 1 " "	+ 2 " "	·144% free
4	5 " "	+ 1 " "	+ 2 " "	·072% free
5	5 " "	+ 1 " "	+ 2 " "	·126% Comb.
6	5 " "	+ 1 " "	+ 2 " "	·063% Comb.
7	5 " "	+ 1 " "	+ 2 "	Water.

That is to say that there there was in

1	·01008 gr. Hll	or	·126%	all combined
2	·00504 gr. Hll	or	·063%	" "
3	·00288 gr. Hll	or	·036%	healthy free
4	·00144 gr. Hll	or	·018%	" "
5	·00252 gr. Hll	or	·0315%	all combined
6	·00126 gr. Hll	or	·01575%	" "
7	·00000 gr. Hll	or	0 %	—

These were placed in the hot chamber at 38° Cent. for half an hour, then were tested with Fehlings solution and with Iodine and Iodide of Potash.

1.	No Sugar	Blue with Iodine
2	" "	" " "
3	" "	" " "
4	" "	" " "
5	Trace of Sugar	Slight violet tinge

6.	Considerable quantity of Sugar	Decided violet tint but not so dark as last.
7.	Sugar with Fehling	No Starch, bright red violet with Iodine

That is to say then that although ·018% HCl, most of it free, for a small quantity may have combined with the proteids of the Saliva, inhibited the action altogether, ·0315% did of it combined allowed of a slight action, while a very considerable portion of the starch was converted in the presence of ·0157% all combined HCl, the process going on probably here more slowly than in the control, No 7, in which all the starch was converted.

No 2 had an acidity of ·063% combined HCl but this sufficed to inhibit the action so that the border line lies between ·063% and ·0315% probably nearer the latter than the former as the amount of conversion was extremely slight, say at ·036% combined hydrochloric acid.

It is clear from this that Starch may be converted in the Stomach, but that only for a very short time, as the acidity soon rises above ·036% combined HCl.

The Digestive power of combined hydrochloric acid.

Huppert and Schütz[79] first enunciated the law that the amount of peptone, here again peptone signifies albumose as well, formed is exactly proportional to the square root of the pepsin used, provided that the supply of Hydrochloric acid is in excess.

In all my experiments in which I have used pepsine, I have argued as if I had added sufficient pepsine to convert all the albumen. In fact I have argued from the acid side of digestion not the peptic side, and I still will continue to do so for I hold on the absence of pepsine in the stomach contents as exceedingly rare and therefore of little consequence clinically.

On the other hand hydrochloric acid is often said to be absent in dyspepsias or in excess and it is the variations of this acid which I regard as the index of the digestive power.

For this purpose I have examined the matter more closely, although I know that the Germans, notably Boas, Sallkowski and Rosenheim, have already noted that the combined HCl is physiologically inert; Sallkowski and Rosenheim as quoted by Tschlenoff[158] seem more recently to have reconsidered their opinion however,

and now believe that it has some digestive power

I hope now to put the matter clearly and on a sound basis, for this I may have to repeat some things I have already written, but it will serve to make the proposition more evident.

I tested the digestive power of the different fluids in the ordinary way as detailed on p. 141 first.

In Chart XIV p. 142 it will be noticed that pure Hydrochloric acid began to appear about the hour and a half after the experiment commenced.

To a few cc's of each fluid withdrawn at the different hours, a few shreds of fibrin, stained by Grützner's method with carmine, washed were added and the flasks, in to which the fluid was put, were kept at 40° Cent for a few hours.

There was no digestion of the fibrin until after pure HCl had appeared in the fluid. At the hour and a half and 2 hours when there was only a trace of pure HCl, there was only a trace of digestion while, in the last two flasks all the fibrin disappeared and the fluid became bright red.

Again a solution of HCl - combined with albumoses and peptones after an act of artificial digestion was used, of an acidity of .576% all combined, with Pepsine added. It had no effect on fibrin. All the affinities of the HCl had been satisfied

Secondly

Three solutions of Hydrochloric acid after a digestion act. were used, 40 ccs of each.

1. ·234% Total acidity ·198% combined, and ·036% free.

A little pepsine and some boiled fibrin added. Fibrin disappeared in a little over an hour.

2. ·477% Total acidity ·468% combined, and ·009% free

Digestion of fibrin slower but complete, although chiefly

3. ·432% Total acidity ·171% combined ·261% free

Digestion of fibrin as in last but not so fast as in the first.

Here then we see that ·036% of free acidity digests fibrin faster than ·261%, and that ·009% free is rather little. The amounts of combined acidity seemed to exert little influence. A possible fallacy however, that the amount of combined acidity present hindered the action of what free there was is disproved by the fact that a solution of ·684% combined HCl was used in another experiment about ·036% of free HCl added and fibrin strips placed in it with a little pepsine. The fibrin was digested quickly.

The combined HCl used hitherto too has been that which has combined during an act of digestion.

Does combined acidity, combined to proteids without acts, but capable of, digestion, act similarly?

2% to egg albumen. HCl be added and the mixture allowed to stand for some time acid albumen is formed and if the proportion of albumen be to the hydrochloric acid above 100 to 7, that is if the acid present be below 7‰, although the albumen is changed so far, yet no free hydrochloric acid is present.

This acid then is combined but is combined in another way to the first, it has not its affinities fully satisfied, and if pepsine be now added to the mixture, and digestion allowed to proceed the acid present, though combined, has power to proceed further, in dialyser experiments at any rate, and convert some of the acid albumen into albumoses and peptones.

This is well brought out in the Experiment p 233
a few pages back. In the last two beakers, in the dialysing tube of the one the digestion of the egg albumen was furthered by the addition of pepsine, even although before that addition all the available acid had attacked the albumen present, as was shown by tube 4, in which the condition of the proteid, of exactly the same amount and with the same proportion to the acid, was not

allowed to go further than that of acid albumen.

As was to have been expected of the 2·04% of proteid available, or in weight 1·8564 gr 3, in No 3 only ·42 gr of acid albumin or parapeptone was recovered, while from 4, the one without the pepsine, ·7314 gr remained on the filter paper.

But in No 3 the same amount of acid albumin was formed as in No 4, in all probability, before the pepsine was added, therefore on the addition of pepsine some part of the acid albumen was further changed into albumoses, found inside, & peptones found both out and in.

In effect then as enunciated on page 240, HCl combined to proteids can and cannot digest them, or further albumenoid bodies, which may be added. If its affinities are not fully satisfied and pepsine be added digestion may proceed even with only combined HCl present.

With all its affinities satisfied no further digestion can occur, unless more free HCl be added.

Part V

Microorganisms.

Chapter I

The microorganisms grown from cases in Ward 29 and elsewhere.

1. List of organisms and sources.

The methods pursued in this part of my inquiry into Gastric digestion are given in Part III (chapter VIII of this essay.

I here give, the names of those organisms which I identified and their characters; the names also of those which are unknown to me; with the source of each & with notes on the cases. The products of some of these organisms on different media will be given in the second part of this chapter.

1. Bacillus Coli Communis. (Bacterium Coli Commune.) This was either the Bacillus itself or the organism identical with it described by Macfadyen[104], the only difference between them being that the true one forms optically active para-lactic acid, the other inactive. I had no means of testing this. It was grown from the Stomach contents of a patient Hodgson who had a dilated Stomach with an acid wash. On entry into the Infirmary the acidity of the Stomach

was as high as ·481 % with free HCl present. The contents were dark, sour and effervescent. The patient had been ill for six years and had pain in the Epigastrium one hour and a half after eating, especially severe after vegetables or beef. He suffered also from flatulence, heartburn and vomiting, and was very costive. The Stomach on examination was found to reach from high up in the left axillary region to midway between the Pubis and umbilicus. The Pain and vomiting were entirely relieved by lavage.

The Bacillus grew on gelatine in small white circular colonies, edges sharp and well defined. In "scratch" cultivations on gelatine it formed a slightly yellow transparent membrane, smooth on the surface and with curved, wavy but smooth edges, well defined. A similar growth on Agar was a little whiter in colour, while on potato it grew as a moist light yellow membrane with edges not so curved as on the Gelatine. Inoculated on milk it coagulated it. The gelatine was not liquefied but in Stab cultures bubbles of gas were formed by the growth along the course of the needle.

The organism was in the form of rods twice to three times as long as broad, not very motile, no spores observed.

The Stomach contents were of ·288 %, acidity the day it was given from them, free HCl present.

I obtained this organism or one almost identical with it from a patient Morrison whose stomach wash was 0·144% acidity, all combined. No free HCl, and no organic acids.

The growths on the various media were the same. Grown on Bouillon it multiplied rapidly, and formed no alcohol, but some lactic acid from a solution of glucose.

2. Sarcinæ Ventriculi

These organisms I isolated from the stomach of the foregoing case Hodgson, they were absent when he was first washed out and when the acidity was very high. After a few days however, with an acidity of .481%, the contents contained a few small sarcinæ; while next day with an acidity of .108% numbers of these organisms grew.

It was with the greatest difficulty that I managed to get the Sarcina Ventriculi to grow on ordinary gelatine, but in bouillon acidified slightly with HCl I succeeded in growing it in quantity.

Always growing in tetrads, and in multiples of tetrads, I never saw any single cocci, as have been said to occur; if healthy, they were somewhat opaque with well defined margins, if attenuated, clear and more homogeneous. Often in old cultures the cells seemed vacuolated and were frequently very granular.

A stomach wash with a sufficient acidity to prevent putrefaction will, if containing Sarcinæ originally, preserve these organisms alive for a long period. I have succeeded in growing them in acid bouillon at 39° Cent. four months after the contents of the stomach had been withdrawn and kept, simply in a corked bottle. All other organisms were dead.

I also grew this organism from the stomach of

another patient, Wm Graham, 64 years old, a quarryman who had had dyspepsia for ten years. With pain and vomiting an hour after eating, an enlarged stomach, he was washed out regularly every evening. The wash at first was hyperacid but not remarkably so, ranging from .315 to .47%. HCl, free HCl present, no traces of other acids. Like the foregoing case there were no Sarcinae at first, but after the acidity of the contents had been brought down by the lavage great quantities of Sarcinae were found. In this case there was a peculiar deposit of crystals in the urine in shape like Tyrosine, and answering the tests for Tyrosine but with no leucin balls. The Sarcinae disappeared later.

In John Penman's case also, who had a considerably enlarged stomach, with hyperacid contents (.409 %) Sarcinae did not appear in any quantity, until he had been washed out several times and the acidity had fallen. They disappeared later. There was some butyric acid free in the contents as well as HCl in this case.

3. Mucor

This organism was also grown from the contents of Hodgson's stomach when the acidity was ·288 %.

Microscopically, oval bodies, staining darkly, growing in a mycelium in this manner

On gelatine the mycelium is poor or absent. The cells are of different sizes, some the size and shape of the ordinary yeast, Saccharomyces Cerevisiæ, others much longer, but of the same breadth.

Grows quickly on gelatine at the ordinary temperature forming white crusts on the surface, beautiful tree shaped, coniferous forms below the surface, exactly like inverted spruce firs covered with snow. Gelatine not liquefied.

In Bouillon grows well in a mycelium form.

On Agar-agar a white growth on surface, slow spreading, coralline appearance below.

In Bouillon anaerobistically it grows very slowly.

On Potato it forms a smooth moist growth, slightly yellow, irregular with raised protuberances ash like.

Does not coagulate milk.

Grows well on bread paste, forming a moist growth of the same colour as the bread, with mycelia.

The growths have no smell.

4. Saccharomyces Cerevisiae

From the stomach contents of a case in Ward 29 Sinclair by name, with an acidity of .15 to .18%. HCl. HCl and lactic present in the free state.

Sinclair was suffering from a simple dyspepsia.

Under the low power of the microscope the colonies on the gelatine were circular, granular and of a yellow brown colour. Under high power large uni-cellular organisms, 10-12 μ with a thick capsule, circular in form in gelatine and milk, oval in Bouillon. Buds from many of the cells.

On gelatine grew in white circular colonies, mostly on surface, if below growing very slowly and in smaller colonies, does not liquefy it.

On Potato, agar-agar, and bread paste grew as white mass, but very slowly.

Anaerobistically in Bouillon grows very slowly. In milk grows well, does not coagulate it. In Glucose solution grows rapidly forming bubbles of gas.

8. A slender Leptothrix

From same case as the foregoing, found along with the yeast.

On gelatine it grows slowly forming, under low power, diffuse colonies, under high power, aggregations of thin filaments, .2 μ broad, some of great length and much curved, twisted and intertwined with others. It does not liquefy the gelatine. On Bouillon it grows in shorter rods, four or five times the breadth.

It is only motile in the shorter forms and then very slightly.

On gelatine the colonies look diffuse to the eye, and grow readily under the surface, are whitish.

In Bouillon it grows fast making it turbid, no smell, some sediment.

Causes Coagulation in milk.

On potato a very slight flat colourless growth.

No spores observed.

Do not stain well with Methyl-violet or with Methylene blue.

Grown from a needle puncture in gelatine form a light cloudiness from the puncture.

Is something like the Bacillus of Mouse Septi-cæmia, except that it forms long threads.

6. Proteus Vulgaris.

This specimen was obtained from the stomach of a child who had been suffering from constant vomiting, and for which I have to thank the kindness of Sir John Thomson.

The fluid obtained from the stomach was small in amount chiefly mucus, contained no free HCl or lactic acid, no alcohol, but was slightly acid in reaction.

The gelatine plates made showed numerous liquefying colonies from which only one organism could be grown.

This grew in circular whitish turbid patches, which under the low power were brownish in colour especially towards the centre, the circumference was clear and not pigmented.

Under high power, short & rod shaped Bacteria were seen, length about twice breadth.

In gelatine tubes the gelatine was soon liquefied entirely the fluid having a yellowish brown colour and a white sediment.

Grown on milk it coagulates it but slowly after 4 days

In bouillon grows quickly and well.

No spores. Motile.

Smell disagreeable, putrefying at first then more of a burnt odour.

7. A small celled yeast Saccharomyces minor?

This organism was separated from the stomach contents of a woman who had two hours before had a meal of bread and milk only. The contents were fairly well digested, with an acetic smell, giving a light brown colour with Uffelmann's reagent. No free HCl or lactic acid. Acidity .324%. Total solids 2.8% Ash .4%, fixed chlorides .0312%. Total Chlorine .3804%.

Next day another specimen was obtained and plates made, the same organism appeared in due course.

The contents on this day were acid, with a trace of free HCl, and of both lactic and acetic acids. The wash was very acid .4%, chlorides .624%. No peptones, but sugar and alcohol present.

The yeast grew on gelatine as a white circular colony which were brownish and granular when view under low powers of the microscope.

On Agar-agar grew as isolated small dry yellow white dots.

On potato formed quickly a yellow white moist growths, raised in centre, edges convoluted irregularly, somewhat like the growth of a Potato Bacillus.

Under high powers the cells were seen to be circular, some clear, others granular, others budding. In size they varied from 5 μ to 6 μ in diameter

8. A large Leptothrix form

This form was obtained from the same case as the last, and on with the occasions.

On gelatine plates it appeared in white ill defined colonies, growing slowly and spreading down into the substance of the gelatine rather than out along surface.

Under low power the colonies were seen to be of a light brownish colour with ill defined edges, no liquefaction of the gelatine occurring.

Under the higher powers Bacilli were seen some short and thick, others long and curving, regular leptothrix forms. The smaller forms were slightly motile.

On Bouillon grew fast, short thick bacilli, slightly motile.

Coagulates milk from the bottom.

Grown in bouillon anaerobiotically the organism grew more slowly in the form of short rods which did not show any signs of movement.

Probably one form of Miller's Leptothrix buccalis.

9. Bacillus Subtilis (Buchner)

Obtained from a woman in the Infirmary suffering from dyspepsia of an indefinite character which was accompanied by Waterbrash. The organism was grown from the fluid ejected which had a slight admixture of stomach contents, no gastric smell however.

Analysis of this fluid showed that it was acid.

Acidity .081%

Chlorides .1248%

No lactic acid, peptone or sugar

Trace of Sulphocyanide of Potassium.

Some alcohol and acetic acid.

The chlorides were all either fixed or in the form of combined chlorine, while of the .081% acid .045% was driven off by heat, presumably acetic acid.

On the plate the colonies were almost colourless the gelatine being quickly liquefied and scooped out in a circular form. Under the low power the colonies were clear at the margins, darker towards the centre, while the organism was seen under the high power to be a bacillus about three times longer than broad, and often growing in chains.

The gelatine was quickly liquefied, the liquefaction being cone shaped apex down, the surrounding gelatine uncoloured, while that part that was made fluid was of a whitish yellow colour, opaque with a white sediment at the bottom of the funnel.

The growth had an offensive odour and a

markedly alkaline reaction.

On Agar-agar it gave rise to a thick white growth with curved edges, moist surface well raised above the agar, very pronounced smell somewhat like stilton cheese.

On Potato as a light yellow moist growth membranelike with curved edges and a cheesy smell. later the growth became dry and wrinkled and air bubbles formed underneath it in places raising up the membrane.

On milk a coagulum was formed but not quickly and it was of a soft crumbly nature, the coagulum just appeared at the surface and 1Blb later. Stale cheesy smell.

The organism stained readily with the ordinary reagents, was slightly motile. Spores observed in old cultures. Length of organism about 5' to 6μ breadth 1½ - 2μ, ends not quite square, slightly rounded

10. Micrococcus candicans.

This organism was in its characters and reactions like the M. candicans or the M. cereus albus.

I obtained it from the stomach contents of a patient who was suffering from Mental tumour probably cancerous and who had his stomach washed out for diagnosis.

He was washed out four hours after breakfast, the contents were ill digested and has a sour smell.

Analysis showed.

Acidity .18%

Chlorides .234% all combined or fixed

No free HCl.

Traces of Lactic and Butyric acids.

No peptone, only a trace of sugar.

No alcohol.

Three plates were made and the following organisms obtained from each.

Of the first variety, the Micrococcus, many colonies appeared, small white and circular with smooth sharp edges looking yellowish under the low power, especially towards the centre of the colonies No liquefaction of the gelatine occurred.

Under a high power the micrococci were seen to be large, arranged in heaps, singly or irregularly No diplococci or streptococci were seen.

Size about 1.1 μ.

In streak cultivations on gelatine first a

this stearin-like growth appeared, which broadened a little, but never spread much over the surface.

In puncture grows on gelatine there was a growth along the track of the needle, white in colour and with a spreading knobby growth at the top.

On agar-agar, a broad dry white growth, slightly raised and with sinuous edges. No smell.

On milk the micrococcus only grew slowly and caused no coagulation.

On potato slight colourless growths, transparent and with sharp, slightly curved edges. Growth became raised and later a few protuberances appeared.

On glucose solution there was a pronounced growth.

On none of these media did the organism produce any smell.

On Bouillon gave a slightly acid reaction, the growth staining a deep canary yellow with Loffler methylene reagent. Without oxygen grew very slowly.

11 A slender bacillus growing in light yellow colonies. Bacillus luteus liquefaciens?.

From the same case as the last organism. On the plates a few small yellow punctiform growths appeared, slowly liquefying the gelatine

Under low powers the colonies appeared as round dark yellow brown growths, with indistinct edges.

Under high powers long thin non-motile Bacilli, four or five times longer than broad.

On gelatine they formed in puncture growths at first a yellow "nail head" growth which slowly formed a funnel, the sediment in the funnel being of a dark orange colour, the liquefied gelatine of a lighter yellow and fairly clear. The surrounding gelatine was not tinged. Little smell.

In streak growths on gelatine small punctiform colonies first appeared, then the gelatine liquefying round them they ran together forming an irregularly scooped out trench.

On agar-agar the growth was of a darker yellow than on gelatine, a membrane with curved edges.

It grew well in Bouillon, the deposit being orange coloured, the bouillon slightly opaque and when shaken giving rise to a "watered silk" appearance.

Milk was not coagulated, but had a bad smell.

On Potato the organism formed a very bright orange yellow, dry, level growth. Bacilli shorter.

Did not grow anaerobiotically or in glucose.

12. Micrococcus

This organism, very similar to the one described as No 10 but differing from it as regards its growth on Bouillon, was grown from the vomit in a case of anaemia with dyspepsia, perhaps atonic.

The patient had been fed on milk alone and the stomach contents were ejected about $\frac{3}{4}$ hour after she had taken some.

The milk was coagulated and had a sour smell.

Acidity .018 %.

No free HCl, or lactic acid.

Smell of Butyric acid

Sugar was present, with a trace only of Peptone and Albumen.

Two plates were made, and two sets of colonies observed in both.

One liquefying the gelatine the other not.

The non-liquefying organism formed round white waxy looking colonies on the gelatine, which under the low power were yellow with smooth sharp edges, under a high power were seen to be composed of moderately large micrococci disposed irregularly, singly or in heaps. No diplococci.

On gelatine, Agar-agar and milk the growths were similar to those of No 10, except that a little peptone was formed in the milk growth.

On Bouillon the Micrococcus grew very

fast, forming a tenacious sediment; the bouillon became very alkaline, with a smell like that of an artificial pancreatic digestion.

The micrococci were as nearly as possible of the same size as those in No 10., they grew but poorly without oxygen.

13. Bacillus fluorescens liquefaciens.

From the same case as last.

Colonies on the plates were at first white specks, then spreading formed shallow depressions in the gelatine which when examined under the low power were at first circular, then more irregular with a dark centre and clear periphery. Under high powers a small actively moving Bacillus, generally in packs.

Puncture cultures on gelatine first gave rise to a white line along course of needle, but the top of this soon became funnel shaped and filled with a greenish turbid fluid with a white deposit. The gelatine round also began to be tinged with green.

The growth went on until all the gelatine had been liquefied

Streak cultures first appeared as white lines

then the gelatine was liquefied along its course, the surrounding gelatine becoming at the same time of a greenish hue.

On Agar-agar the growth from a streak culture spread over the surface of the medium as a white raised moist and fleshy membrane while the agar below became gradually coloured a livid green. This green lasted some weeks, but as the culture became older gradually faded leaving the agar a dark and dirty yellow-brown.

On potato there was a yellow, uniform and dry growth with only a slight discoloration of the substance of the potato close by.

The growth on gelatine had no very marked smell.

On Bouillon grew slowly, green colour badly marked. White deposit and slight smell present.

Anaerobistically little or no growth.

14. Pink Torula. Rosahefe.

The case from which this and the next organism was grown had a somewhat dilated stomach and suffered also from a consequent dyspepsia

On the 8th of April 1894, his stomach contents had an acidity of ·288% , free HCl being present.

No alcohol.

Some peptone and sugar

A trace of lactic and Butyric acids.

Tested about four hours after last meal, of bread and milk.

Three tube plates were made, but nothing grew. next day however after a similar meal and at the same time the stomach contents on analysis gave the following result

Acidity ·216% HCl.

Free HCl ·0312%

Combined acidity ·162%

Organic acids ·0138%

No lactic acid.

Trace of Butyric

Peptone and sugar present

Alcohol doubtful.

Two plates were made in the ordinary way, and after three days a few white round colonies grew which I identified easily as the Saccharomyces Cerevisiae. Other pink circular colonies also appeared which proved to the "Rosahefe" of the Germans

The colonies under the low power were circular and granular, the organisms circular under the higher powers.

The growth on gelatine in puncture cultivations showed a pink head at the surface and a whitish growth along the track of the needle, consisting of a string of white beads.

On Agar-Agar it formed a slightly pink dry growth on the surface.

It grew in milk but did not coagulate it.

It also grew but sparingly in bouillon, more luxuriantly in a glucose solution.

Anaerobiotically in bouillon it failed to increase unless glucose was added.

This organism also occurred in the stomach of a case of Cancer tested on May third, 1891, along with other organisms. The acidity in this case was very slight, no free HCl being present.

15 Bacillus Wissen?

This germ grew from a specimen of the stomach wash of the same patient as last, but the stomach contents were much more acid. Analysis showed that it contained eggs, mucus and charcoal, he was taking charcoal as a medicine,

Total Acidity .432 %
Free acidity .144 %
Combined acidity .288 %
Free HCl present
Traces of lactic acid.
No alcohol, butyric or acetic acid.
Peptones and Sugar present.

Two tube plates were made, and in both one or two white round, non liquefying colonies with curved edges appeared, and these were found to be pure cultivations of one somewhat large sized Bacillus.

Under low power the colonies are light brown not quite round with edges somewhat indented but strongly marked by shadows.

Under high powers the bacilli were seen to be large curved and growing often in curved strings of many individuals like .

On gelatine it grew as a knob on the surface in puncture growths, the growth along the track of the needle being slow and discontinuous.

In streak cultures white round knobs appeared which growing quickly coalesced and formed a wet

very broad growth. No smell or liquefaction.

On Agar-agar a large white growth appeared, fleshy and knobby, like milk drops coalescing. Gave rise to little smell.

On Bouillon the bacilli grew in more curved forms, gave rise to no smell and grew moderately quickly.

Anaerobistically grew very partially and slowly.

On milk the caseine became slightly coagulated on the top, but the process did not spread down far.

The organism grew but not luxuriantly in a glucose solution

It is difficult to classify this organism as it has few distinctive features. It is evidently extremely resistent to acids.

16. Bacillus.

This organism is of interest in that it was only after three attempts from the same patient that I could get any organism to grow.

The patient, Ballingall, had a somewhat dilated stomach with hyperacidity, principally HCl.

On the first day, 29/4/91, about four and a half hours after food, 9b oz were withdrawn from his stomach and analysis showed the following;-

Acidity .414%	Free HCl. .0624%
Combined acidity .324%	Total Chlorides .4992%
Free acidity .09%	Combined Chlorides. } .4368%
	Fixed Chlorides. }
	Free Organic acids. .0276%

Trace of lactic acid present.
No Butyric or Acetic acids.
Peptones very distinct.
No alcohol or glucose present.

Two tube plates were made but nothing grew

On 1/5/91, two days after the analysis showed

Total acidity .324%	Free HCl .018%
Combined acidity .306%	Total Chlorides .4992%
Free acidity .018%	Combined and Fixed Chlorides } .4812%
	Free Organic acids. 0.

Peptones, and glucose present, alcohol absent.
Again two plates made. No result.

5/5/91.

Acidity	·216%	Free HCl	·048%
Combined acidity	·168%	Total Chlorine	·3744%
Free acidity	·048%	(combined and fixed (chlorides)	·3174%

Free Organic Acids. 0.

Peptone present, glucose and alcohol absent.

Two plates made.

Growth of a large Bacillus which liquefied the gelatine slowly. It was a pure cultivation.

The colonies on the gelatine were at first somewhat knobby, and in a streak cultivation gave rise to a thick white creamy growth which gradually eat into the gelatine and in time liquefied that part near it.

Under a low power the colonies were exactly like Leucin balls, dark brown circular and striated plates with irregular rough edges.

Under a high power the Bacilli were seen to be broad some long, some short, often in chains. Non-motile.

The streak cultivation on gelatine at a later stage consisted of the same creamy substance as before floating in a small amount of fluid in a shallow trough of gelatine.

On Agar, a slow white dry growth formed, broad; with large Bacilli in chains and heaps.

On Potato; a yellow brown dry growth. The centre became darker than the edges which were irregularly rounded.

17. Thin Leptothrix

This form was grown from the same patient as No 16. but on a different occasion.

The stomach contents had the following features.

17/5/91.

Total acidity	·216%	Free HCl	·0312%
Combined acidity	·18%	Total Chlorides	·3744%
Free acidity	·036%	Combined and Fixed Chlorides	·3432%
		Free Organic acids	·0048%.

Trace of Lactic acid, no butyric or acetic acids. No alcohol, trace of peptone and glucose present.

Small white ill defined colonies grew in the plates, not liquefying the gelatine.

They formed in bouillon small white cotton wool like masses in the fluid.

The organism was a very thin leptothrix form, smaller than the previous one described, No.

Its further properties were not investigated.

18. Bacillus similar to the Bacillus coli communis, but with much more uneven and irregular margins in its growth on gelatine.

This organism was grown from the stomach contents of an alcoholic patient in Ward VI, the contents were neutral, no free HCl, but had a gastric smell.

The organism grew on gelatine with a thin spread out growth, whitish but transparent, the edges of a growth from a streak culture being excessively contorted and irregular in their fashion.

The gelatine was not liquefied.

This organism produced lactic acid in milk.

On agar, a soft moist growth with dentate edges.

Under high power are seen to be Bacteria the length one and a half times the breadth. Non motile or only very slightly.

19. Bacillus liquefying gelatine quickly with a turbid, yellow colour.

On the gelatine plates from the last case an organism was cultivated which formed on the gelatine a whitish yellow growth, which however soon liquefied the surrounding medium. The yellow colour of the liquefied gelatine is not so pronounced as in the case of no 11, and it is turbid. In no. 11 the liquefied gelatine was clear, a bright yellow deposit or growth lying at the bottom. In the present case again the growth was very rapid. There was a slight, but distinct putrefactive odour.

Under low power, dark centre, light edges to the colonies.

Under a high power the bacilli were seen to be of different lengths, usually the length however is to the breadth as 2 to 1. They were non-motile.

On Agar; the organism formed white moist growths like mucus. Slightly yellow in parts.

On Bouillon, some lactic acid was formed and the growth was fairly rapid.

20. Aspergillus niger

This species was grown from the stomach contents of a case of malignant disease of the pylorus.

The acidity of the contents was .27%, with no free HCl, but Lactic and Butyric acids present.

It grew on gelatine liquefying it and giving it an alkaline reaction.

From the same case a micrococcus was grown, but it was neither investigated further or identified.

21. Bacillus.

Grown from the same case as the last on another occasion. Analysis of the stomach contents gave

Total acidity	.18%	Free HCl	0
Combined acidity	.18%	Total Chlorine	.1248%
Free acidity	.0	Combined and Fixed Chlorine	.1248%

Free Organic acids. .0652%.

No Butyric or Acetic acids. Lactic present.

Only a trace of peptone and glucose, no alcohol.

The organism grew on gelatine as a transparent slightly fluorescent or opalescent growth with edges sharply defined, and slightly toothed or indented

Under a high power, short Bacteria are seen, with rounded ends, almost micrococci, slightly motile.

On Bouillon, the Bacteria are longer and longer. There is a slight smell of cheese.

On Potato; a yellow moist growth, raised. The bacteria here form short rods with rounded ends, very slightly motile, tending to form heaps; no spores.

On milk, Some caseine coagulated, but not much. Organisms longer.

On Agar, a white moist growth with edges rounded in large curves.

Most of the cultivations had a pronounced cheesy smell.

Except on potato, the growths of this organism are colourless.

22. Bacillus Septicus Agrigenus ?

An organism which corresponds in many particulars to the above was grown from the stomach contents of another Cancer patient, Lockie by name.

The analysis of the stomach contents was as follows:—

Total acidity	Combined acidity	Free Acid.
·144 %	·126 %	·018 %
Total Chlorine	(combined and fixed Cl.	Free Cl.
·1872 %	·1872 %	0.
Lactic acid	Butyric acid	Acetic acid
·018 %	0	0.

An agar tube was inoculated and made into a plate tube, so also two gelatine tubes. The agar tube plate was kept at 38.° Cent.

On both forms of plate the organism grew.

On gelatine the colonies formed thin, widely spreading films, and in a streak culture a very thin delicate growth spreading rapidly from the centre, the edges curved but hardly visible. Non-liquefying.

Under the low power the colonies were rounded slightly yellow colonies with darker centres.

Under the high power, bacilli, length 3 to 4: breadth 1. Occur singly or two or three together.

On Agar, form colonies, like drops of cream slightly and tenacious, round in form.

On Bouillon, grows rapidly, great growth of long and short threads, non motile, with no spores.

May form threads of some length on gelatine.

23. Large motile Bacillus, liquefying gelatine slowly.

Grown from the same case and on the same occasion as the last species.

The colonies on the gelatine were knobby, white, and cream like.

Under the low power they had light brown centres, edges clearer but sharp.

Under high power, large motile bacteria, exceedingly active on the warm stage.

The growths on gelatine slowly liquefy that medium. In stroke cultivations just some small wax like drops appear, then run together forming a long wax like streak, dry ish at first and papular with curved edges. Later on the gelatine liquefies slowly, the growth of the organism still forming a pellicle on the surface. In punctiform cultivations the pellicle forms a white ring clear in the centre, white round, floating on the surface.

This organism was not investigated further.

24. Bacterium lactis aërogenes

This organism was grown from the same patient and at the same time as nos 4 and 5.

On gelatine there were a number of small white thick colonies, some round, some slightly irregular.

Under the low power the colonies are round, yellowish, do not liquefy the gelatine, have smooth refracting edges, somewhat granular.

Under the high power bacteria were seen non-motile, with rounded ends; they were short and broad.

On potato; a white layer, sometimes with gas bubbles underneath

On milk; coagulates it quickly. no smell.

On Bouillon; grew well.

A case of especial interest is the following; The stomach contents from a patient who had suffered from continued severe hiccough for some time was siphoned off pure. He had not taken anything by the mouth for 10 days, but had been fed solely by the rectum.

A small quantity of slightly opaque acid fluid was procured which contained no free HCl, nor any of the organic acids, but was slightly acid. There was no gastric smell observed, nor any peptone or glucose.

An agar plate was inoculated and two gelatine plates, also a tube of Bouillon.

On the first the only organism observed was the Proteus Vulgaris. On the Gelatine plates four organisms were separated out.

1. Rosahefe; a mill yeast.
2. Bacterium (Bacillus) Coli Communis
3. A small called Yeast.
4. Proteus Vulgaris.

From another case, one of suspected cancer of the stomach, various organisms were grown.

Analysis of the contents showed

Total acidity	Combined Acidity	Free Acidity
.09%	.09%	0.

There was no free HCl, but a trace of Lactic acid.

Gelatine tube plates were made and the following organisms grown.

1. Rosa hefe, in great numbers

2. Bacillus fluorescens liquefaciens (No 13)
3. A mould; greenish-yellow in colour.
4. Bacilli similar to Bacillus Coli Communis.

—4—

Table of Microorganisms with the acidities of the stomach contents from which they were grown.

Microorganism.	Acidity. (Maxima) Total.	Combined	Free.
1 Bac. Coli Communis	·288%	–	–
2 Sarcina Ventriculi	·108%	–	–
3 Mucor	·288%	–	–
4 Saccharomyces Cerevisiæ	·18%	–	–
5 Slender Leptothrix I	·18%	–	–
6 Proteus Vulgaris	Trace	Trace	0.
7 Saccharomyces Minor	·324%	·288%	·036%
8 Large Leptothrix	·324%	·288%	·036%
9 Bacillus Subtilis	·081%	·036%	·045%
10 Micrococcus Candicans	·18%	·15%	·03%
11 Bac. Luteus Liquefaciens	·18%	·15%	·03%
12 Micrococcus	·018%	·018%	?
13 Bac. Fluorescens Liquefaciens	·018%	·018%	?
14 Rosa Lepra	·288%	·162%	·054%
15 Bacillus (Weisser?)	·432%	·288%	·144%

16. Bacillus.	·216 %	·168 %	·048 %
17. Very thin leptothrix.	·216 %	·18 %	·036 %
18. Bacillus like the Bacillus Coli Communis.	neutral	-	-
19. Liquefying Bacillus	neutral	-	-
20 Aspergillus niger	27 %	27 %	—
21. Bacillus, non-liquefying	·18 %	18 %	-
22 Bacillus Septicus agrigenus?	·144 %	·126 %	·018 %
23. Large motile Bacillus	·144 %	·126 %	·018 %
24 Bacterium Lactis Aerogenes.	·18 %	-	-

2. Products of the microorganisms grown from stomach contents on various media.

I now proceeded to investigate the products of the organisms which I had grown and which are enumerated in the last section.

The methods employed were those explained at the commencement of this essay, and need not be recapitulated here.

The different media were inoculated with pure growths of the different organisms, the products being analysed when evidence of considerable growth appeared.

The results are as follows:—

1. Bacillus Coli Communis;

Acidity of stomach contents ·288%.

Products on a

a. Bouillon aerobically. No smell, bouillon is acid, ·108% as HCl, Lactic acid present, no Butyric or Acetic. No Sugar.

b. Bouillon anaerobically. No smell, no colour, acidity more marked, ·126% as HCl, Lactic and perhaps Acetic acids.

c. Milk rapidly coagulated with the formation of Lactic acid.

d. Gelatine; gas formation below surface of the gelatine.

Remarks; There was no trace of Lactic acid in the

stomach contents on the day on which it was given. But as the acidity in this case diminished under treatment Lactic acid made its appearance.

2. Mucor ;

Acidity of Stomach wash, .288 %. No Lactic acid.

Products on

a. Gelatine ; slightly alkaline reaction.

b. Bouillon ; no reaction, no alcohol.

c. Bouillon (anaerobically). neutral.

d. Milk ; very faintly acid, no smell, nor alcohol, peptones nor Lactic acid.

Remarks : no special products were noted.

3. Sarcina Ventriculi.

acidity of stomach wash .108 %.

Products on

a. Gelatine ; it became acid.

b. Bouillon ; the acidity increased, I could not identify the particular acid.

c. Milk ; no change.

Remarks ; grows very slowly out of the body, the products are scanty.

4. Saccharomyces Cerevisiae.

Acidity of Stomach wash ·18%. free HCl and Lactic acid being present.

Products on

a. Gelatine; ?

b. Bouillon; Neutral reaction.

c. Milk; sweet smell, no peptone or Lactic acid, neutral reaction, a trace of alcohol.

d. Glucose solution; CO_2 and alcohol.

5. Slender Leptothrix

Acidity as in last.

Products on

a. Bouillon; formation of Lactic acid with perhaps a trace of acetic, acidity ·108% as HCl, Alcohol present. No Butyric acid or sugar.

b. Bouillon (anaerobically.) Similar products acidity not so pronounced. No alcohol.

c. Milk, coagulated, very acid, ·162% when filtered, brown colour with Löffelmann ? acetic acid, no alcohol or peptone.

No smell or colour.

Remarks;- this was grown from a stomach whose contents comprised some Lactic acid. No 24, the Bacterium Lactis Aerogenes was also grown from it. These two organisms probably account for the presence of the Lactic acid.

6. Proteus Vulgaris.

Acidity of stomach contents, trace.

Products in

a. Bouillon; it became alkaline.

b. Gelatine; alkaline, brown colour, no peptone, green with Fehling's solution, no sugar, a trace of alcohol.

c. Milk; coagulation after four days only, clot not firm, shreddy, no peptone, alcohol, lactic acid or sugar. Stains a brown colour with Lyffelmann's reagent, acidity ·108%.

7. Saccharomyces Minor.

Acidity of stomach wash ·324% (·036% HCl)

a. Bouillon; neutral.

b. Glucose; CO_2 and alcohol.

8. Large Leptothrix.

Acidity of stomach contents ·324% (·036% HCl). Acetic present.

Products, a. Bouillon aerobically, grows fast, no sugar, lactic acid or alcohol. Acid, ·09%. Brown with Lyffelmann.

b. Bouillon anaerobically, acidity ·09% HCl, bright canary yellow with Lyffelmann, that is, lactic acid, no sugar or alcohol. Peptone present.

c. Milk coagulated from the bottom, lactic

acid, form of acid doubtful.

Remarks;— it is curious here that, grown on bouillon with air, this organism should evidently produce one form of acid, without air another.

It is also noteworthy that the contents of the patients stomach from which this organism was grown evidently contained Acetic acid, shewing, as it did, a bright brown with Uffelmann's reagent.

There is usually some oxygen present in the stomach from swallowed air, this organism then might well have been the origin of the acid.

9. Bacillus Subtilis.

Acidity of gastric contents ·08%, per ·04%.

Products on

a. Gelatine; alkaline reaction, putrid odour, some alcohol and much peptone. No Lactic acid, or Butyric. No H_2S.

b. Milk; soft coagulum forms, with a cheesy smell, but no butyric acid or H_2S. Trace of Lactic present, acidity ·01% HCl. Peptones distinctly present. Alcohol doubtful.

c. Potato; alkaline reaction, large bubbles of gas.

10. Micrococcus Candicans.

Acidity of Stomach wash ·18%, as per titl.

Products as

a. Bouillon, slightly acid reaction, canary yellow with Löffelmann, Lactic acid.

b. Milk. no coagulum, slightly acid no peptone or Lactic acid.

c. Glucose, aerobically alcohol.

d Glucose, anaerobically alcohol and a trace of acid, Lactic?

e. Bouillon anaerobically trace of Lactic acid.

Remarks;- this organism seems to have the power of producing some alcohol from glucose.

Traces of Lactic acid were found in the gastric contents.

11. Bacillus luteus liquefaciens. (so called).

Acidity of Gastric Contents ·18%. as per titl, as in last.

Products as

a. Bouillon; becomes slightly acid, with a trace of Lactic and acetic acids.

b. Bouillon anaerobically. no growth.

c. Gelatine; alkaline, slight stale smell no alcohol.

d. Glucose; no growth

e. Milk; is not coagulated, no lactic

or Butyric acids, exceedingly bad smell. Acidity ·07%.
Some peptone formed.

Remarks;—

This organism then can peptonise milk slightly, without coagulating it, cannot grow without air, and produces some acidity.

12 Micrococcus;

Acidity of Gastric contents ·018%.

Products on

a. Milk. Trace of peptone formed, milk becomes slightly acid, is not coagulated.

b. Bouillon; becomes strongly alkaline = ·252% HCl acidity, peptones very prominent no alcohol.

c. Bouillon anaerobically, grows badly, results doubtful.

Remarks;— The strong alkalinity of the bouillon growth is worthy of remark, as is the presence of peptone in the growth on milk. No acids seem to be formed.

13. Bacillus fluorescens liquefaciens.

Products not investigated.

14. Rosa bacteria.

Acidity of stomach contents. 1. ·216% (·054 per)

2. ·09% HCl per HH.

Products on.

a. Milk; no coagulum, peptone present, milk acid, with trace of lactic acid. Smell of caramel.

b. Bouillon; neutral, white opalescence with Uffelmann's reagent. No increase of peptones, no alcohol.

c. Glucose; acid; alcohol and lactic acids present.

Production of a bright pink if air be admitted.

15. Bacillus. (Weisser?).

Acidity of Stomach contents, ·432% ·144% HCl.

Products on

a. Bouillon; alkaline, peptones seem increased.

b. Milk; acid ·072%, trace of peptone and of lactic acid. Slight Coagulum.

c. Glucose; trace of acidity, perhaps lactic and acetic.

21 Bacillus non-liquefying;

Acidity of gastric contents ·18% HCl per HH.

Products on,

a. Bouillon; acid, ·072%, lactic

and Butyric (?) acids present. no alcohol.

b. milk: acid, .18%, peptones present, some coagulation. Trace of lactic acid.

19. Liquefying Bacillus.

Acidity of Gastric Contents nil.

Products on

a. Bouillon, slightly acid, trace of lactic, no alcohol.

b. Glucose; no alcohol, no growth.

18. Bacillus like the B. Coli Communis.

Acidity of Stomach contents, .144%. no curdle,

Products on

a Bouillon, slightly alkaline, no alcohol.

b. Glucose; slightly acid, trace of lactic acid, no alcohol.

c. milk, acid, lactic acid present.

24. Bacterium Lactis Aërogenes.

Acidity of Stomach contents, .18%;

Products on.

a Bouillon, acid, lactic acid present.

6. Bouillon, anaerobically; acidity ·108%, Lactic and Butyric acids very distinctly. No alcohol.

c. Milk; coagulated, acidity ·162%. No smell or colour. Lactic acid present. No alcohol or peptone.

In testing the products I did not endeavour to identify any further bodies than those I had been in the habit of looking for in the contents of the stomach. That is to say, the different organic acids, sugar, peptone and alcohol.

The number of organisms whose products gave the tests for Lactic acid was surprisingly large; if the original test, Uffelmann's was doubtful, the fluid was shaken up with Ether and the Ether extract tested.

On several occasions was there strong evidence of the presence of Lactic acid in the stomach contents, from which Lactic acid forming bacteria were grown.

The following table gives the different organisms with their products; also the original constituents of the stomach contents from which they were grown.

Table showing the products of the Microorganisms.

Microorganism	Stomach Contents	Products on Bouillon 1. aerobically	2. anaerobically	Products on Milk	Products on Gluten Solution	Products on Gelatine.
1. Bacillus Coli Communis	Very acid, no organic acids	Acid ·108% Lactic acid	Acid ·126% Lactic acid Acetic ?	Lactic acid		Bubbles of gas.
2. Mucor	Very acid.	None	None	Slight acidity		None.
3. Sarcina Ventric.	—	Acidity increases	None	None		Becomes Acid
4 Yeast.	No alcohol. Lactic acid	Neutral	None	Trace of alcohol	O_2 & C_2H_6O.	?
5. Slender Leptothrix	Lactic acid present	Acid ·108% Lactic & Acetic Alcohol	Acid. Lactic & Acetic	Acid ·162% Acetic ?		
6 Proteus Vulgaris	Slightly acid.	Alkaline	Acid ·108% Acetic ?			Alkaline alcohol ?
7 Saccharomyces minor	Acetic acid.	—	—	—	O_2 & C_2H_6O	—
8 Large leptothrix	Lactic and Acetic acids.	Acid ·09% Acetic acid	Acid ·09% Acetic and Lactic acids	Acid .?	—	—
9 Bacillus Subtilis	Alcohol	—	—	Acid ·078% Lactic acid a trace. Peptotoxin		Alkaline. alcohol. foul odour.
10. Micrococcus Candicans	Traces of Lactic & Butyric	Slightly acid Lactic Acid	Trace of Lactic acid	Slightly acid	Aerobically Alcohol anaerobically Trace of acid	
Bacillus 11. Luteus Liquef.	Trace of Lactic & Butyric	Slightly acid.	—	Bad smell. acidity ·072 Some peptone	—	Alkaline
12. Micrococcus	Trace of Butyric	Strongly alkaline	—	Trace of Peptone Slightly acid.	—	—
14 Rosa Hefe	Trace of Butyric	Neutral	—	Slightly acid. Peptone present Lactic acid ?	acid. alcohol and perhaps a trace of Lactic	—
15 Bacillus	Very acid.	Alkaline	—	acid. ·072% Trace of Peptone	Trace of acidity	—
21. Bacillus	Lactic acid	Acid ·072% Lactic acid	—	Very acid ·16% Peptotoxin. Lactic	—	—
19 Bacillus	Neutral	Trace of Lactic	—	—	—	—
18 Bacillus like B. Coli Communis	Neutral	Alkaline	—	Lactic present Slightly acid	Slightly acid	—
24. Bacterium Lactis Aerogenes	Lactic acid present	Acid. Lactic.	Acidity ·108% Lactic and Butyric	Acid. ·162% Lactic Acid	—	—

A glance at the foregoing table will show that the lactic acid, which appears during the first stage of digestion in the stomach, may readily be formed by the numerous microorganisms present.

Again in the case in which there was some acetic acid noted in the gastric contents, an organism was grown (No 8.) which seemed to have the power of forming acetic acid from the nutrient media on which it was cultivated.

Several of the growths on milk became surprisingly acid as for instance Nos 5, 21 and 24, there were .162% .18% and .162% respectively. A number of the organisms also produced peptones from milk, Nos. 9, 11, 12, 14, 15 and 21. The other media having had peptones added before cultivation, no observations on the peptonising power of the organisms were made on them.

3.

The effect which the presence of microorganisms in quantity has on digestion.

I was led to look into this matter by the obvious derangement of the processes of nutrition which I observed in several cases of dilated stomach with much fermentation. Also Macfadyen in his paper on digestion and organisms in the small intestine draws attention to the subject. While it is a popular fallacy among those whom I may call "demagogic physiologists", to say that a great deal of our digestive processes is attributable to microorganisms. This is purest rubbish.

Bearing in mind the assertion of Richet and his school that the "Acide chlorhydrique combiné organique," might be a hydrochlorate of Leucin I looked into the subject of the presence of Leucin among the products of peptic digestion.

I failed to find it. Evaporating down the contents of stomachs to a syrup gave no positive result. Nor did treatment with Acetate of lead and H_2S, with subsequent evaporation.

In no case of artificial gastric digestion could I identify this substance.

In Morrison's case (cf p 198) I was not quite sure on one occasion whether there was any

Tyrosin present in the stomach contents or not.

I then performed an experiment with peptic digestion in the following manner. Using a dialyser, I placed inside the tube of parchment many test tube growths of different micro organisms both on gelatine and broilon. The particular organisms made use of were some of those I had already grown from the stomach contents of patients and comprised cultivations of the B. Coli Communis, Proteus Vulgaris, B. Subtilis etc etc. Some fibrin and fresh gelatine was added with a pinch of pepsine. Outside there was 300 ccs of a .3% solution of HCl. The contents before digestion had a very powerful and disagreeable odour.

After five hours there was no evident smell and on evaporation neither Leucin nor Tyrosin could be found inside or out.

In this next experiment I used pancreatic digestion and the questions I set before me for answer were

1. Does the presence of micro organisms in quantity impede pancreatic digestion?
2. Is the formation of Leucin and Tyrosin under these circumstances increased or decreased?

Experiment.

I used a control experiment here using thing

being similar except the presence of microorganisms

1. (control;

40 ccms of Bouillon + 3 gms of dried fibrin were placed inside a dialyser tube with 4 ccs of the liquor pancreaticus of Duncan Hockhart and Co.

Outside the tube were placed 100 ccms of a Sodium Carbonate solution .3% .

2.

40 ccms of Bouillon + 3 gms of dried fibrin were placed inside a similar dialyser tube. In the Bouillon were growing B. Coli Communis, Bacillus Subtilis, Bact. Termo, yeasts and mucors etc. 4 ccs of the Liq. Pancreaticus were added.

Outside the tube 100 ccs Na_2CO_3 .3% as before.

After six hours the contents of the tubes and the fluids round them were measured, and analysed.

The contents of the dialysers we will call a. (No 1) and c. (No 2.); the fluids outside, b. (No 1) and d. (No. 2.)

a. On boiling; deposit of albumen and globulin; in small quantity .32 gs; filtrate clear yellow, filtered quickly and easily.

Filtrate on drying 1.5 gs; ash .2 gs; = 1.3 gs. On examination of the fluid some leucin balls could be seen under the microscope.

6. Fluid somewhat turbid, but filters easily, no albumen present. 87.5 ccms in bulk.

Total solids from the filtrate 1.76 gr of which .353 gr is inorganic, that is 1.407 gr organic.

Under the microscope small crystals of Leucin and Tyrosin were visible.

C. Fluid has a very evil smell, between a rotten cheese and addled eggs. 58. ccms in bulk.

Albumen and Globulin = .621 gr.

Total solids from filtrate 1.31 gr of which .18 gr was inorganic, leaving 1.13 gr organic.

Under microscope no Leucin or Tyrosin; many microorganisms.

d. Fluid has a very bad smell, filters slowly and badly. Contains 86 ccs.

Total solids from filtrate 1.667 gr, of which .371 is ash leaving 1.296 gr organic.

Under the microscope the residue shows no Leucin or Tyrosin; no organisms.

Table of Results

Without microorganisms

In. 1.3	}	Organic Soluble constituents after acidifying and boiling.
Out. 1.407	}	
.32.		Albumen or Globulin.

Leucin and Tyrosin present.

With microorganisms

In 1.13	}	Organic. Soluble constituents after acidifying and boiling
Out 1.296	}	

·621 Albumen or Globulin.

to Leucin or Tyrosin.

That is to say then, that in answer to the two queries I put to myself, I found that micro organisms, when present in quantity, decrease the amount of albumen peptonised to an appreciable degree, while they appear to inhibit the formation of leucin and Tyrosin.

I repeated this experiment. In doing so however I proceeded to amplify it, subjecting the organisms and the control to a preliminary gastric digestion. The details are as follows.

I used the same apparatus as formerly, two dialysers. The organisms used were also as before.

1. Control;

40 ccs of Bouillon and 6 gs of moist fibrin = 2·04 gs of dry fibrin and some pepsine, inside the dialyser tube. Acidity ·075%.

200 ccs HCl solution ·072% (= ·144 gs HCl) outside.

2.

40 ccs of Bouillon, in which many organisms were growing, 2·04 gs of dry fibrin and some pepsine, inside the dialyser tube. Acidity ·079%.

200 ccs HCl solution ·072% (= ·144 gs HCl) outside.

Digestion was allowed to go on for five hours at 102° Fahr., the beakers and their contents were then placed in a cool place until next day.

Analysis.

1. Without Organisms. Control.

Inside; Acidity in 55.5 ccms = .068 % = .03774 gs.

Acidity after evaporation = .054 %

Free acidity = .014 %.

Free HCl present, only a trace however.

Outside; 188 ccs = .054 % acidity = .10152 gs.

No free acid.

Total solids .51 % = .9588 gs

Ash .07 % = .1316 gs.

Combined Chlorine in Total Solids = .10152 gs.

Organic solids = .72568 gs.

2. With Organisms.

Inside; 51 ccms; acidity .107 % = .05456 gs.

Acidity after evaporation = .09

Free acidity = 018 %

Free HCl present.

Outside; 192 ccms, = .045 % acidity = .0864 gs

No free acid.

Total solids .38 % = .729 grms

Ash .0786 % = .152 grm.

Combined Chloride in Total Solids. = .0864 grm

Organic Solids = .5906 grm.

The first part then of this experiment shows that the presence of microorganisms in large numbers inhibits gastric digestion to some extent.

That is to say that the diffusible organic matters, presumably to a large degree peptones, are increased in the contents, diminished in the other. Both the specimens gave the Biuret reaction strongly.

—

5 ccs of the fluids inside the dialyser tubes had been used to calculate the acidities. The remainders were used in the Second Stage.

1. Contents without organisms.

50·5 ccs placed inside, a pinch of pancreatine being added; 5 ccs of an 8·5% Glucose sol. added also.

Outside 200 ccs of a solution of $NaCO_3$ rendered slightly acid by the addition of Acetic acid Acidity ·09% HCl.

2. With Organisms.

46 ccs placed inside, a pinch of pancreatine added and 5 ccs of a 8·5% Glucose solution.

Outside 200 ccs of a $NaCO_3$ solution with Acetic acid added up to ·09% HCl acidity.

Digested for four hours at 102° Fahr.

---

1. Without organisms.

Outside; 193 ccs. ·025·2% acidity.

After Evaporation alkaline ·045% HCl.

Total Solids ·296 %
Ash. ·141 %
Organic Solids 1·65 % = 3·1845.

Glucose present, peptones and acetates.
No leucin or tyrosin.

Inside Acid at first.
Alkaline after evaporation. ·036 % HCl.

2. With Organisms.

Outside. 193 ccm.
Acidity ·0288 %
After evaporation ·072 % alkalinity.
Sugar, and peptones present. No tyrosin.
Total Solids. 2·84 %
Ash. 1·34 %
Organic Solids 1·5 % = 2·895 gr.

Inside
Acid at first but alkaline on evaporation.

I added the acetic acid in the second stage to test Macfadyen's assertion that digestion in the small intestine goes on normally in acid media. The acids in nature being the organic acids formed by Bacteria from the food.

In this case the acid did not deter the pancreatine and $NaHCO_3$ from working.

It will be again noticed that the diffusible matters were in greater quantity in the control than in the specimen containing the micro organisms.

That the organisms had not wholly been killed by the previous gastric digestion I proved by cultivating them successfully on gelatine.

I then used the contents of the dialysers for a third stage, using outside a plain solution of $NaCO_3$. The details were exactly similar to those of the previous stages.

Third Stage.

1. Inside without organisms present.

60 ccs, + a pinch of pancreatine.

Outside 200 ccs $NaCO_3$ solution .4% alkalinity.

2. Inside with organisms present

56 ccs, + a pinch of pancreatine.

Outside. 200 ccs $NaCO_3$ solution .4% alk

After digestion for four hours at 102° Fahr the contents were analysed when it was found that in No 1 there was only a trace of organic matter and proteids inside the dialyser and a very small quantity outside. The figures are No 1 Inside 66 ccs.

Total Solids	.91%	
Ash	.8%	
Organic Solids	.11%	= .0726 gr.

No 1 outside. 185 ccs.

Total Solids. 1·93%

Ash 1·42%

Organic Solids ·31% = ·5735 gr.

There was a considerable quantity of organic material, compared with No 1, inside the tube in No 2 and the organisms, having grown again with increased vigour, the contents had a bad smell.

No 2 inside. 60 ccs.

Total Solids 1·5326%

Ash ·96%

Organic Solids ·5726% = ·3435 gr.

No 2 outside 184 ccs.

Total Solids 1·3913%

Ash 1·1013%

Organic solids ·29% = ·5336 gr.

Remarks

All through this experiment the presence of the microorganisms seemed to cause a diminished output of diffusible proteids, and the organic material contained in the dialysing tubes at the end of the experiment was in part serum albumen or globulin in No 2; in No 1 no proteid coagulable by heat was found.

Of course the microorganisms used may by their action on proteids form by products which are difficult of digestion, or what is more likely they may by their presence induce the formation rather of anti-albumoses than of the hemi-compounds, thus preventing much further digestion.

In the control experiment the small amount of organic material left inside the tube at the close of the experiment consisted almost entirely of albumose, probably in the form of anti-albumose.

In the experiment with microorganisms there was a very considerable amount of albumoses, besides the albumin, more than .2 gr.

Though these experiments are not conclusive they afford a little insight into the conditions present in the stomach when fermentation is going on.

Of course digestion itself is looked on as a fermentation. It is natural then that the presence of one fermentation should impede the other.

4. A note on the effect the organic acids have on Pancreatic digestion.

Though strictly speaking this subject should not come under or be included in an essay with the title of Studies in Gastric digestion, yet it follows so closely on that which has just gone before that I feel justified in including it.

Seeing that in some disordered states of Gastric digestion fermentation may go on to a considerable extent, that Lactic and acetic acids may be formed, and that the organisms which can produce these acids may reach the duodenum alive, it became a question to determine what effect these acids had on the Pancreatic fermentation.

Macfadyen loc. cit. has already, indeed, pointed out that at the lower part of the ileum the contents of the small intestine are acid. He attributes this to the organic acids formed by organisms, and also regards these same acids as powerful antiseptics. That in fact the organisms are kept in check by their own products.

For this purpose I performed six digestion experiments in flasks, varying the acid used in conjunction with the Carbonate of Soda.

The following are the details.

I took 6 flasks, added to each some fibrin and a solution of $NaCO_3$ in water. The solution of $NaCO_3$ in each flask was of the same strength ·3b % (HCl). To each flask, except no 5, a certain amount of acid was added, sufficient in each to make the contents acid.
To each flask pancreatine was added.

Flask	Fibrin	$NaCO_3$	Acid.
1	·402 gr.	20 ccs.	HCl.
2	·4 gr.	20 ccs	Acetic acid
3	·4 gr.	20 ccs	Acetic acid
4	·403 gr.	20 ccs	Acetic acid & HCl
5	·407 gr.	20 ccs.	No acid.
6	·4 gr.	20 ccs	Lactic acid.

The acidity of each flask was as follows, just before digestion as above, secondly after digestion had taken place (during six hours in an incubator at 102° Fahr.).

Flask.	Acidity at once	Acidity afterwards.
1	·504 %	·45 %.
2	·324 %	·288 %.
3	·144 %	·09 %.
4	·126 %	·054 %.
5	—	—
6	·072 %	·036 %.

The acidities were tested with Phenol-phthalein.

The result of the digestion was as follows

Flask	albumen	acid albumen	Albumose	Peptone
1	·09	·31	0	0
2	·4 ?	?	-	-
3	·048	?	·2	·056
4	·014	-	·1	·132
5	·172	-	·12	·109
6	·012	-	·2	·14.

The forms of albumose were different in the different flasks.

Flask

1 none

2 none; perhaps some alkali albumen

3 Proto and deutero

4 Hetero, small amount of Proto + deutero

5 Proto and Deutero

6. Proto, no hetero.

Result; judging by the amount of albumen left unchanged, no 5, or the flask without acid added, was the one in which least digestion took place.

When acetic acid is present in sufficient quantity to render the solution acid to the extent of ·28% no digestion or very little takes place, as in no 2. But if the resulting acidity is

only ·072 % a considerable quantity of albumen is changed into the simpler proteids.

Hydrochloric acid in the first absolutely inhibits any digestion, but in No 4, — in which acetic and hydrochloric acids were added in equal quantities — an acidity of ·144 % before digestion, — ·072 % after — fails to prevent a large quantity of the fibrin from being decomposed.

Lactic acid in slight excess seems to facilitate the process of pancreatic digestion as seen in No 6.

This is a subject which merits further and much more accurate investigation than I was able at the time to give to it. I hope on another occasion to pursue the inquiry.

The result however of this single experiment, with Macfadyen's remarks might lead physiologists to modify their ideas about pancreatic digestion. I believe that we must look more to the organic acids in the intestines — that is, in the small intestine — for the necessary antiseptic, than, as most physiologists, to the Bile.

It is surprising how often the statement is repeated that bile is a powerful antiseptic. One thing is certain, no physiologist who

assents that it is so, has ever kept a specimen of it standing on his table for two days. By that time, age, before it, it stinks.

Some other antiseptic then must be present in the small intestine, for the contents of that part of the gut have little putrefactive odour and have other evidences of the presence of some antiseptic.

If pancreatic digestion can go on in the presence of organic acids, if these organic acids are present in sufficient quantity to act antiseptically, the mystery is solved.

Part V.
Microorganisms.

Chapter II

Microorganisms grown from cases in Ward 29 and elsewhere.

1. Their behaviour under Digestion.

At present the tendency is to give the stomach the credit of a greater antisepticity and a less digestive power, indeed some go so far as to assert that it is purely ornamental, a survival from earlier times, when such an organ was indispensible to the form our ancestors had then attained to, and by no means useful. Its digestive power is disparaged, its antifermentative power questioned.

If the Stomachs of carnivorous or omnivorous animals were so useless, by this time I am sure they would have managed to dispense with them.

Czerny however kept a dog alive for years after he had removed its stomach, and the animal was quite lively, seemed to have no difficulty in extracting sufficient nutriment for its wants from its food and passed fæces very similar in character to the usual in any excrement of a dog.

However that may be there is no getting round the fact that the acid contents of the Stomach have

a distinct antifermentative action, especially on certain forms of minute organic life.

After perusing McFadyean's results, detailed on p 53. I thought they could easily be worked out with greater accuracy and with more similarity to the actual nature of things, if, instead of growing the organisms in closed flasks, I were to use dialysers outside of which I could put an HCl solution while inside I had my cultivation growing in a suitable nutrient medium. I first devised, to carry out this plan, the following apparatus, a circle of parchment was folded like a filter paper, the resulting cone suspended in a glass beaker holding three litres of water with HCl added, and the whole placed in an incubator at the body temperature. After I had performed a few experiments in this wise, I happened to read Sheridan Lea's 98 paper on the increase of the digestive powers of an artificial digestive juice if an apparatus were used which allowed the diffusible products to escape. In this paper Lea advocated the use of parchment sausage tubes procured in Germany. I at once got a supply of these, and found them to answer admirably.

To return again to McFadyean's results, he found that certain strengths of Hydrochloric acid killed certain micro organisms. He used for the purposes of his experiments some of the better known

and more easily identified organisms, while all his experiments were conducted <u>in vitro</u>. The fallacy of arguing absolutely from these it at once apparent, the organism, unused to life in media of such an acidity, is soon killed. Again the acid is added to a nutrient material containing more or less proteids, part of the acid combines with these proteids and loses in great part its anti-fermentative power, this proportion of combined and free acid is not ascertained and if ascertained is constant and not, as in nature constantly varying.

On the other hand, if the acid be allowed to dialyse slowly into the solution, if the products of digestion be allowed to dialyse out, for with 3000 ccs outside the capacity for taking out the peptones from 50 to 100 ccs. may be regarded as infinite, if at first, as is the case, the dialysed acid combines with the proteids, no free acid being found inside, and if the total acidity inside rise almost to that out, free acid only appearing an hour or an hour and a half after the experiment has been begun, similarly to what occurs in life, (cf p), then the conditions present more closely approximate to those in nature, though they may be still far removed from it, and the study of the growth of micro organisms under these conditions is more likely to repay the trouble entailed and to lead to more accurate results.

When using such an apparatus of course I could not sterilise it absolutely, but to my mind rigid sterilisation is not so necessary for these experiments, for in life no pure culture of one organism can exist in the stomach —— although now and then one is only able to grow one variety from the contents —— and the growth of one necessarily influences the growth of another, acid, excessive growth of one as surely inhibits the growth of others as the most powerful antiseptic. The organism that is best suited to the environment flourishes the best, and this applies both to the contents of the stomach and to the fact — noted a few lines above —— that with many organisms present, sometimes only one variety will grow in any numbers or even at all on the nutrient media employed. There is something in fact that offends its sense of the fitness of things, the gelatine is too strong or too weak, too cold or too hot, too alkaline or too acid or may be, it should be fluid, or firmer, or have some glucose in it or what not. I do not argue then about the organisms which were present in the stomach, only those which I succeeded in cultivating from it. The stomach itself is kept fairly aseptic by the acidity of its contents, I sterilised the parchment tubes in the same way, washing them with a solution of HCl first, then with absolute alcohol, then dried them. The fluid outside did not require sterilising for in the first place it was a solution of HCl,

while secondly organisms seem unable to pass through the pores of parchment. The nutrient material was as a rule Beef broth, with commercial peptone — largely albumose — and glucose added. It was always carefully sterilised beforehand. In many instances also small threads of fibrin or cubes of white of eggs were added. The Pepsine used was either the Pepsina Porci, carefully dehydrated over H_2SO_4. Then heated to 80° Centigrade on one or two different occasions, it remained quite active after this, or the Pepsinum Hucleum of Messrs Duncan Flockhart & Co which was active and thoroughly aseptic, even after keeping for a considerable period. The dry pepsine before sterilisation contained a large form very similar to the Bacillus Subtilis which, being very resistant to acids, soon overpowered any other microorganism present.

The microorganism, on which I wished to test the effect of the acid, was grown beforehand on sterilised Bouillon, a considerable quantity added to the fluid in the parchment tube the ends of which were at once closed and the tube lowered into the acid solution already warmed to 35° – 40° Cent. A cover was now put on and the whole apparatus placed in a large incubator with a water jacket, the temperature of which was kept at 40° Centigrade as nearly as possible during the whole time of the experiment.

When I wished to test the contents I removed the cover dipped a previously sterilised platinum wire into the contents of the tube and with it inoculated the tubes of nutrient material, while a few ccs were withdrawn with a sterilised pipette for examination of the acidity and form of acidity. The usual times for such examinations were every quarter of an hour for the first hour, at the hour and a half, and at the second, third, fourth and sometimes fifth hour after the commencement, and then as a rule the apparatus was left untouched for 24 hours, when another examination was made.

The points I kept before me in the experiments were, 1. to arrive at the exact acidity at which the ordinary inhabitants of the Stomach were inhibited or killed.

2. To determine the different effect of the different forms of acidity.

3. To test for the products of the Bacteria during the digestive process.

4. To use these experiments as a contribution to the matters discussed in Part IV of this essay, namely the causes and forms of acidity and digestion in dialysers.

5. To identify the common organisms found in the stomach and find their products

when grown on different media.

To enable me to perform these experiments I had, of course, in the first place to grow organisms from stomach contents and identify them. MacFadyean worked only with well known organisms, the Staphylococcus Pyogenes Albus the Micrococcus Prodigiosus, the Cholera and Typhoid Bacilli, but, bearing in mind their bearing on dyspepsia, I determined to investigate the character and conduct of organisms procured directly from the stomachs of dyspeptics. The methods of sterilising the apparatus used and of procuring the gastric contents are detailed in Part III and need not be repeated here.

To familiarise myself with the process I have indicated above I first used the Staphylococcus Pyogenes Aureus which MacFadyean found was killed by a solution of HCl of .3% in strength.

I performed four several experiments on the same lines, the Staphylococcus was added, — from a growth in bouillon — in bulk to a nutrient fluid containing gelatine, fibrin, egg albumen and water to which a small quantity of sterilised Pepsine had been added, this placed in the Parchment tube and suspended in 3000 ccs of HCl solution, in each of a different strength.

In No 1 .036% HCl

2. ·265 % HCl

3. ·342 % HCl

4. ·54 % HCl

The acidity of the solution inside before being suspended in the acid was ·036 %, no free acid being present.

The course of the experiment is very clearly shown in Chart XVI. (p. 361)

The presence or absence of free HCl, lactic acid and in the fourth experiment the quantity of free acid were estimated whenever the total acidity was titrated, and gelatine tubes were made at the same time.

The acidity inside became greater than that out in all four cases, in the first immediately in the second and third at the first hour and in the fourth not till the third hour. The free acidity or rather the free HCl did not appear in the first experiment until the fourth hour, due to the weakness of the acid outside, in the other cases it appeared from before one hour to an hour and a half. A trace of lactic acid was detected at the beginning of two of the series. The Staphylococcus survived twenty four hours of the first acidity, which never rose above ·108 % with only a trace of free HCl, but was killed between the 2nd hour and the 2½ hours in the other three, where the acidity varied between ·306 % and ·414 %. In the case in

the acidity was ·414% about ·0935% was probably free. It is only rarely that the human stomach contains a fluid of so high an acidity, never in a normal state unless after a heavy proteid meal and then the acid will be chiefly combined.

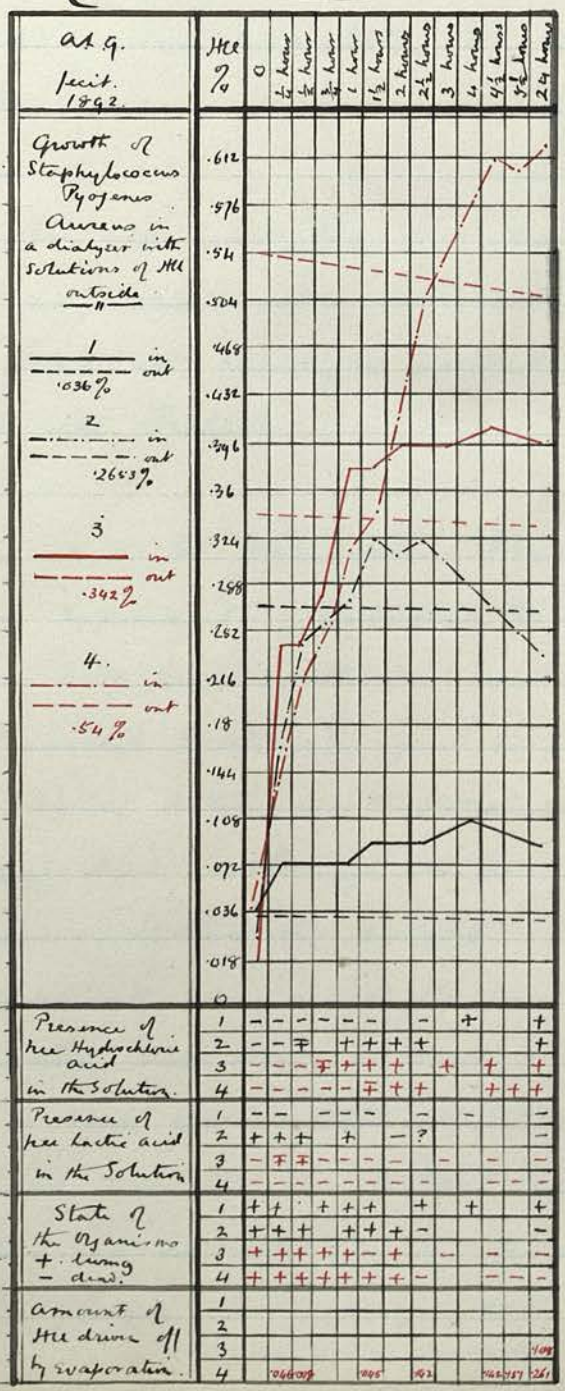
·324% of combined acid and ·0935 of free sufficed to kill the Staphylococcus Pyogenes Aureus, but it takes a much higher percentage of combined HCl alone to kill it, and I regard the presence of the free acid here to be the principle agent at work, for I by a simple experiment was able to show that a much higher percentage of HCl all in a state of combination was incapable of killing this organism, although it inhibited its growth to a certain extent.

I made a solution of HCl combined with the proceeds of the gastric digestion of Fibrin, in which there was no free acid but the total acidity of the fluid was ·684% with a slightly greater quantity of Chlorine. On sterilising this after filtration I obtained a clear bright yellow heavy fluid, in which the Staphylococcus grew, not luxuriantly, but steadily.

The Staphylococcus Pyogenes Aureus then is very resistent to the action of HCl combined with Proteids although if a comparatively small quantity of free acid be present

it succumbs. It is to be noted again that a less amount of free acid is required to influence it, if combined acid be present as well. MacFadyean found the limit to be ·3 % but of course did not state anything about the fact of some of the acid being combined.

Chart. XVI



On examination of the Chart it is seen that the Organism lived through the digestive act in No 1, and died in the three others about the same time. Again it will be noted that free acid was present in each case before the Organism was killed.

The Solution of Gelatine acidified that Macfadyen used contained probably only a very small quantity of free acid and the organisms were placed at once in it.

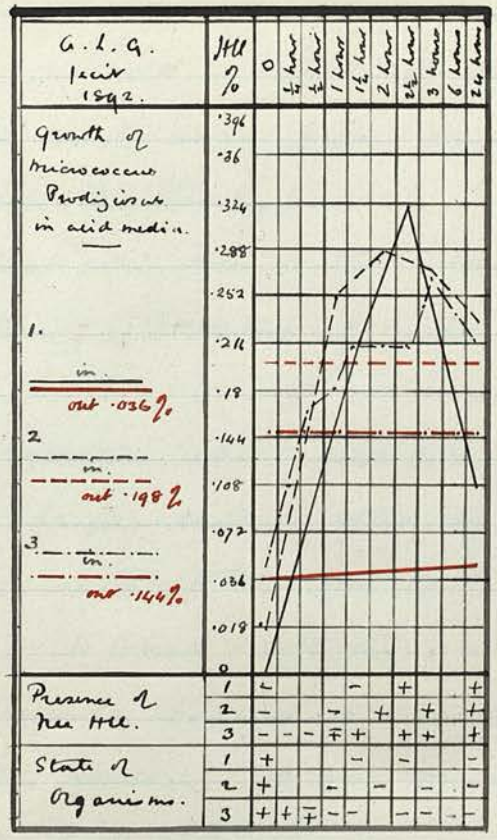
From this experiment then it is seen that HCl has a very considerable antiseptic power when free, and not nearly so marked a power when combined with Proteids.

I also used the Micrococcus Prodigiosus for a similar experiment. Unluckily the Pepsine I added was not perfectly sterile and a large variety of Bacillus Subtilis (?) grew in the fluid. I could however determine the point at which the Micrococcus died, although the presence of the other may have initiated the result.

This experiment was one of the first I tried so is naturally defective in some particulars. It will be seen however that this Organism is not nearly so resistent as the last in no case living as long as an hour in the acid media.

Macfadyen found that .05% HCl killed the

Chart. XVII



Organism. In No. 3 of my experiments it lived until the acid inside reached above ·162% at the ¾ hour, and even then only a very few colonies grew.

The details of these experiments are seen in Chart XVII, the different acidities outside being

·036% HCl

·198% HCl

·144% HCl.

The acidity inside ran the usual course, the greater rise in No 1 being due to the greater

concentration of the material inside, no 2, being comparatively weak. Free acid appeared earliest in no 3, but it will be noted that the micrococcus died in each case before any free acid appeared, unlike the Staphylococcus. The conclusion one must come then is that this organism is very sensitive to the action of acids free or combined.

Note, the organism which grew from the Pepsine in this case, a large bacillus, often in chains, was extremely resistant to the action of acids, living after digestion for 4 hours with the acidity rising to .36%. Usually however it was dead at the end of the 24 hours. It was probably originally a denizen of a pigs stomach.

The next organism experimented with was the Bacterium Coli Commune (Bacillus Coli Communis.)

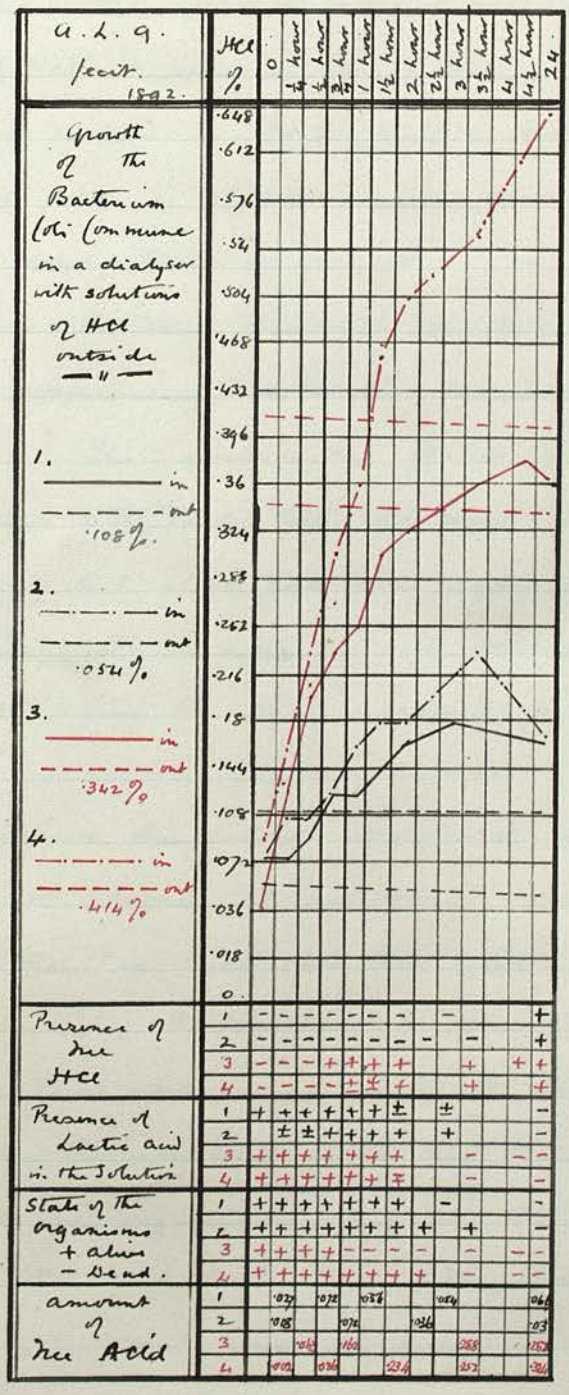
The details of the experiments are precisely the same as in the last.

The acidities outside were 1. .108%.
2. .054%
3. .342%
4. .414%.

Inside nos 2 and 4 were the most concentrated, the nutrient media being in all Bouillon, gelatine, citrin, water, and in 2 and 4 some milk.

The course of the experiment is shown on Chart XVIII

Chart. XVIII



The peptone used in this and in the succeeding experiments was rigidly sterilised before use.

The course of the acidity in each case is represented by the curves now so familiar.

It will be noticed that free HCl does not appear in the first two until after the normal period of digestion is over, but that it appears much sooner in the last two. Sooner indeed in No 3 than in No 4 although the acidity of 3 is higher because the contents of 4 are more concentrated.

Lactic acid is very distinct in this experiment, as a rule appearing until the micro-organisms are killed. The explanation of its disappearance later is due to the fact that no more being produced inside, that which has been produced beforehand dialyses through the membrane. The resulting solution is too weak to give the tests required to prove its presence.

The organisms themselves correspond closely with the presence or absence of free HCl. In 4 they live longer than in three, but then, although the acidity is higher, the free acid in 4 does not make a decided appearance until the second hour.

Judging by the acidities in the other three, I believe that, though no organisms grew at the third hour in No 1, yet if I had been able to make some more plates, I would have succeeded in rearing some colonies at that hour.

The experiment as a whole then shows that this organism is fairly resistant to HCl.

that it can live through a digestive act for at least 3½ hours with acidities of ·144% to ·236%. no free HCl present, but some lactic acid.

Also that it is not killed until the 2½ hours with an acidity rising to ·522%, much of it free HCl; or again until the first hour with an acidity of ·234%, of which free HCl forms a part.

I next submitted the Bacillus ~~[illegible]~~ to the action of the acid. p.295

I performed two experiments with this organism.

The media inside was as in the previous experiments, no 2 however being much more concentrated than no 1.

The acidities outside were

no 1. ·054%

no 2. ·182%

The result is depicted in the black lines on Chart XIX.

It will be seen that the organisms are not very resistant to free HCl, in both cases I was unable to grow them immediately free HCl made its appearance inside the dialyser tubes.

Lactic acid is present at the beginning of each experiment.

The exact acidity at which the organisms were killed is as follows, in no 1. between

the $\frac{3}{4}$ of an hour and the first hour, acidity between .144% as the chlorine combined, and .144% with a small quantity of free HCl.

In No 2, the organisms did not wholly succumb until the hour and a half, the acidity being .342% with only a trace of free HCl.

On the same chart in red the results of the growth of another organism, No 9 in last section, is depicted. This organism is probably the variety of Bacillus Subtilis described by Buchner. The cultivation used, one on broth, had a very evil smell.

In this series the same nutrient media were made use of, No 1 being concentrated, No 2, weak. The acidities outside were

No 1. .072%

No 2. .162%

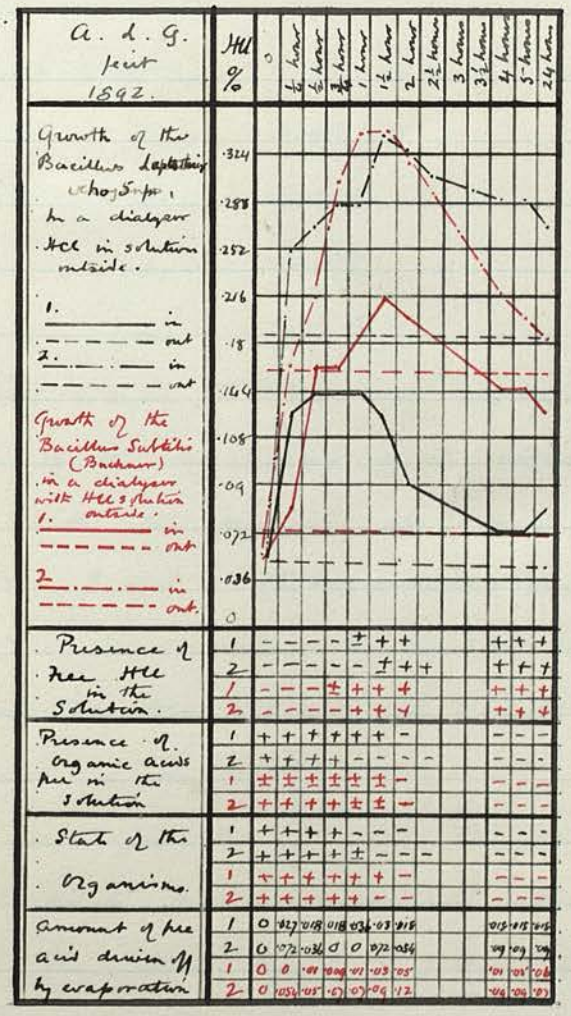
Comparison of the results, as shown on the chart, shows that this organism has very much the same resistance to HCl as the last had, the period of death being coincident with the appearance of free HCl in the solution containing it.

The contents of the tube continued to smell until, in No 2 the second hour, i.e. about an hour after the organism could be cultivated; in No 1, the $2\frac{1}{2}$ hours, also about an hour

after the probable death of the bacilli.

The Bacilli lived then in no 1 until ½ hours, with the acidity ·216%, some per acid presence, in no 2 till the first hour, acidity ·342, free HCl just present.

(Chart. XIX.



Similar experiments on the Bacterium lactis Aerogenes, and Proteus Vulgaris, and their results have already been noted in Chap I of this part. The results are depicted in Charts VII and VIII (pp 110-111) respectively.

With regard to the first, the acidities outside were

1. ·036%
2. ·054%
3. ·108%
4. ·504%.

The media inside the tubes were as before.

The life of the organisms again corresponds very closely with the presence or absence of free HCl. In nos 3 and 4 the organisms only lived about $\frac{3}{4}$ of an hour, when the acidity had reached ·234%, some free HCl present, in 3, ·612% with free HCl present in no 4.

They lived in no 1. until the fourth hour but then the acidity present never rose above ·09%. in no 2 on the other hand they lived to an hour and a half, when the acidity was ·108%, free HCl just present.

Lactic acid was present in all, but in no 4, was only appreciable for a short time.

The experiments on the other organisms were very similar. The acidities outside were

1. ·072 %
2. ·108 %
3. ·234 %
4. ·52 %

This organism was not so resistant to the action of acids as were some of the others.

In tubes 1 and 4, no colonies grew after a quarter of an hour, in both of these the nutrient media had purposely been made weak. In 2 and 3 on the other hand, with a more concentrated pabulum, although few HCl appeared soon, the organisms grew until about the second hour.

The acidities present at the last period at which any colonies were grown were as follows;

1.	¼ hour	·072 %	No few HCl.
2.	1½ hour	·126 %	Few HCl present.
3.	2½ hour	·306 %	Few HCl present.
4.	¼ hour	·378 %	No few HCl.

There was never more than a very problematical trace of lactic acid in any of the experiments.

I was unable, from want of time or opportunity, to undertake any more experiments on the resistance of the organisms which I had separated from the gastric contents. I had purposed at one time of submitting all the Bacteria I had separated.

to the action of HCl and digestion.

The experiments I have done however are sufficient both in number and in similarity to prove the antiseptic[illegible] of the contents of the normal stomach to be less than thought to be the case from experiments with pure HCl.

Resumé of the results of Part V and application of some of them to dyspepsias.

1. Many organisms have been grown from the Human stomach.
2. I have cultivated many from very acid stomach contents.
3. In many cases in which organic acids were present in the stomach contents, I could obtain micro-organisms which produced the same acid on suitable media.
4. Most of the organisms so grown were very resistant to the action of acids.
5. HCl organically combined has little inhibitory action on organisms as compared with pure HCl.
6. More micro-organisms can be grown from the gastric contents if plates be used, the medium of which does not liquefy at the body temperature, than if plates

of gelatine be employed. Agar-agar is a good vehicle. The yeasts and mucors however can be grown best in Bouillon first and then isolated from gelatine plates.

7. Micro-organisms, if present in quantity, exercise a deleterious effect on both gastric and pancreatic digestion.

8. That, though the fatty acids have a strong antiseptic action, they exercise rather a helpful influence on pancreatic digestion. On the other hand they impede the combination of HCl to proteids in peptic digestion.

9. That pathogenic organisms, usually very markedly affected by HCl, may pass through the stomach unharmed, if the meal with which they are ingested be large and chiefly proteid in character. Provided also, it may be from some particular circumstance, that the supply of HCl be somewhat deficient. Under such circumstances most if not all the acid combines. It follows from no. 5 that organisms of all varieties will reach the intestines unharmed. The most favourable circumstances for this to happen, which I can imagine, is after a public dinner, if the dinner be below par.

10. That many non pathogenic germs do as a matter of course pass through the stomach

either unharmed or only temporarily inhibited. This accords with Macfadyen's observation that the Bacteria in the small intestine are constantly changing in numbers and varieties.

11. I have shown the utility of using dialysers in such experiments, allowing the HCl to be added constantly and slowly, as the needs of the substance to be digested require it, the speed of diffusion varying, as it probably does in nature, directly with the strength of acid used.

12. As regards the life of microorganisms I believe that this method of adding the HCl, almost exactly simulates nature, whatever be the difference in the manner in which it is secreted. The constant motion of the stomach walls and contents were not simulated, therefore the acidity, especially the combined, rose more slowly.

13. From the first experiment on Beyrie I have shown the progressive diminution of microorganisms during the hours of an ordinary digestive act in which the acidity rose to .306 % HCl, .216 % of which was combined, and again to .396 %, .342 % combined. But notwithstanding this acidity some still sur-

-vived at the end of the digestive act.

14. Again, although combined HCl is not so active against Bacteria as the free acid, still it is not without influence, as a smaller quantity of free acid, if combined acid be also present, is sufficient to kill or inhibit the organisms, that when free acid is present alone. This follows from a comparison of Macfadyen's results and my own.

15. Micro-organisms are of no use, rather the reverse, in the course of peptic digestion. They are somewhat of a hindrance in the duodenum to the pancreatic ferment, if in any quantity. Bacteria are, however, of use in the intestines, especially in the small intestine, to prevent putrefaction. This seeming paradox, microorganisms obstructing micro-organisms, rises, I believe, from the fact, which I have clearly brought out and which I wish to emphasize, that the organisms which produce acid are naturally most resistant to the action of acid. This is noted with regard to some of the organisms by Hüppe and Sims Woodhead. These organisms, then, pass the searching examination of the stomach in large numbers, while

many of the other varieties. both pathogenic and non-pathogenic succumb to the evanescing acid. The surviving microbes multiple and produce fatty acids. These acids are sufficient to keep the putrefactive organisms in check. In the large intestine the secretion is so alkaline that the putrefactive organisms reassert themselves.

16. The lactic acid, which appears during the first period of digestion is due to the action of organisms.

17. The lactic, acetic, butyric and succinic acids found in Gastrectasis are due also to organisms, which luxuriate in the too stationary contents.
As is the marsh gas, now and then observed, the Brennender-gas of the Germans. (I have seen one case of this but could not get any organisms for cultivation.)

18. Increased putrefaction in the intestinal canal may be due, in cases, either to insufficient mortality among the putrefactive organisms in the stomach, or to too great mortality among the acid forming bacteria and yeasts.
((corollary of 15.)

19. With regard to the particular organisms the results are tabulated on p. 334. and need not be again referred to.

20. Many of them however were capable of forming acid products anaerobically.

Part VI.
Inductions

Chapter I.
The nature of the process of gastric digestion of Proteids.

Bunge[6] in his book on physiological chemistry gives in an admirable passage the different theories with regard to the secretion of hydrochloric acid. This does not concern us here to any great extent, but the theory that it is formed from the NaCl in the blood by the carbonic acid in that fluid is fascinating. He points out that it follows the law in chemistry, that a weak acid has power to convert the salt of a stronger acid into the component acid and a corresponding salt, in very small quantities

That is that;—

$$2NaCl + CO_2 + H_2O = 2HCl + Na_2CO_3$$

We still, however, are no nearer an explanation of how the HCl, if thus formed, is passed into the cavity of the stomach while the Na_2CO_3 goes into the blood current. May it not have something to do with the attraction proteids have, and therefore protoplasm, has for HCl.

The acid combines with the protoplasm of the cells in the mucous membrane of the stomach, and part of this can be discharged in the free state into the cavity of the organ. Osmosis, as I have shown, is amply sufficient to dissociate a small quantity of free acid from the combined.

The process then may be a combination of selection and diffusion, all the time being under the sway of the nervous system.

S. Waymouth Reid[126] has lately shown that in experiments with living animal membranes interchange takes place between two fluids, separated by such a membrane, without osmosis, if there be considerable pressure employed. That in fact the cells themselves seem to take part in the process.

Such may be the case in the stomach, but the subject of osmosis during life requires further and much more careful study.

Be the manner and mode of secretion as it may, the fact remains that free HCl is constantly being poured out during an act of digestion.

If the substance to be digested contain proteid the acid combines with the proteid material.

In time, as digestion proceeds, all the proteid has combined with acid and then free HCl appears in the contents.

At this time, however, the total acidity increases more rapidly than the free. Why?

Because though all the proteid material has combined with acid, it has not done so to the full extent of its capacity, when in the presence of pepsine.

At this stage, then, the increase of acid required to combine with the higher albumens, to split them up into the lower albumoses and peptones, is rather less than the free acid available. Or in other words, more free acid is being secreted, than is required to form simpler bodies from the more complicated albumens, to which already some acid had attached itself.

The total acidity therefore rises quicker than the total free-acid, for part of the free acid is constantly being used in the digestion.

The free acid is not used up, it only becomes organically combined, and may afterwards be dissociated again.

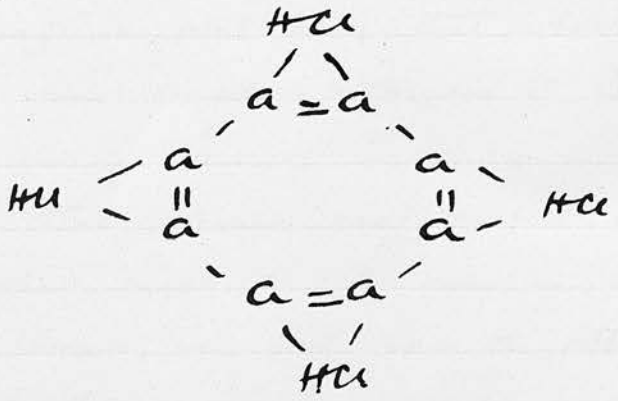
As I have shown the simpler proteids combine with acid, but the proportions are not at all uniform. As a rule the amount of acid which combines to albumens, albumoses and peptones is about the proportion of 4:6:8 respectively.

May not this lead to some vague sort of idea as to the relative size of the molecules

of these substances; —

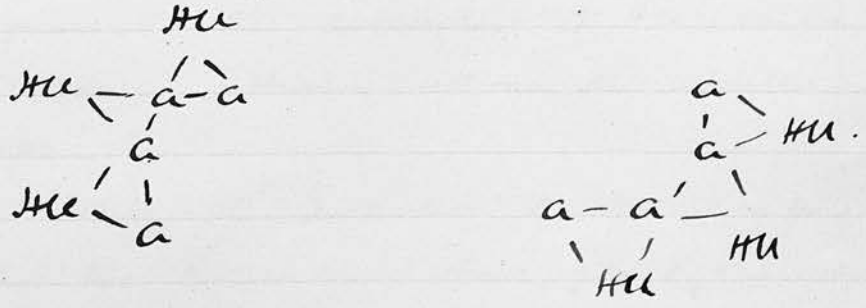
Say for instance that albumen is a substance composed of compound molecules, to which HCl combines in certain proportions; this proportion varying with circumstances, but, all things being equal, in a constant relation to the amount of HCl combining with the simpler proteids.

I may represent my supposition thus in a graphic manner; —



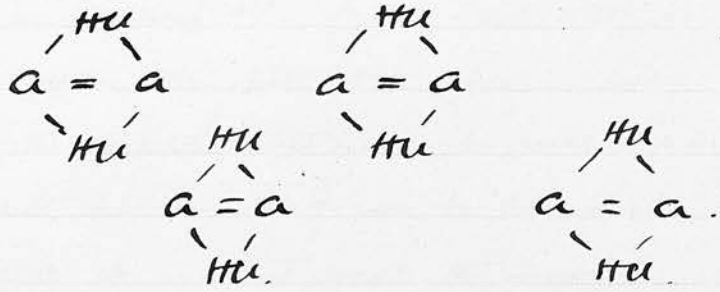
In this problematical group a represents the simplest proteid molecule.

In the presence of pepsine and hot HCl this group may be split up thus; —



Which might represent the albumose group

and which is further split up in the presence of pepsine and yields HCl into



It will be seen that the amount of HCl combined to the compound molecule at the beginning is just half that which is combined to the four simpler molecules of Peptone at the end.

But these figures are simple compared with what must be the case in nature.

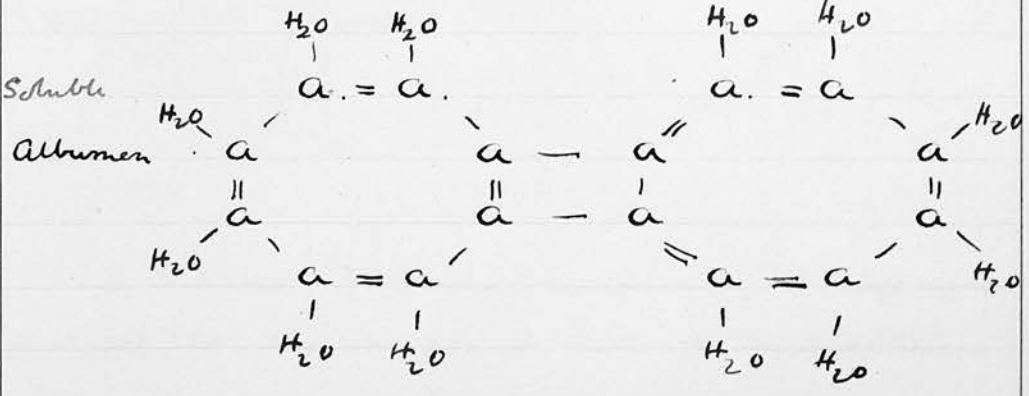
If, however, we look upon the albumen molecule, that is the compound molecule, as 1496, (with Hecksel,) while HCl has an atomic weight of 36·5, four molecules of HCl are just 9·7% of the albumen molecule. cf. Bunge loc. cit.

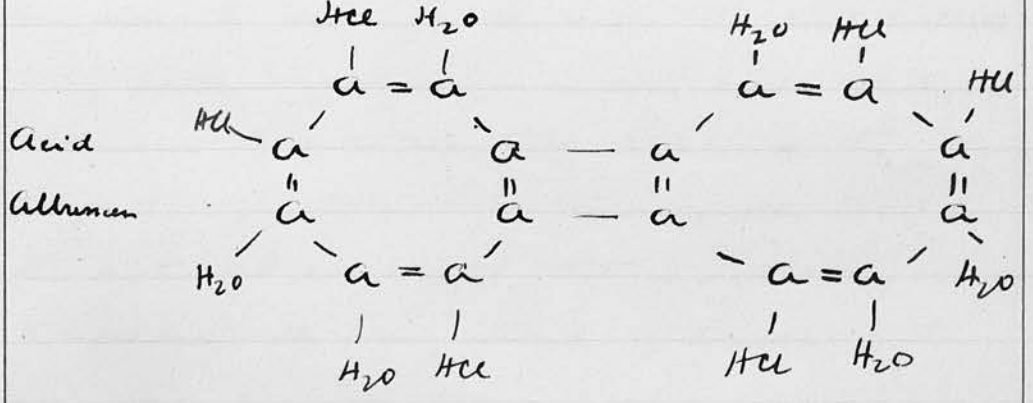
9·7% is just about the figure which represents the percentage of HCl combining to serum-albumen without the addition of pepsine.

While the proportion of HCl combined to the two molecules, which, joined, represent pepstone, is just 19·5%, also close to the figure found by experiment.

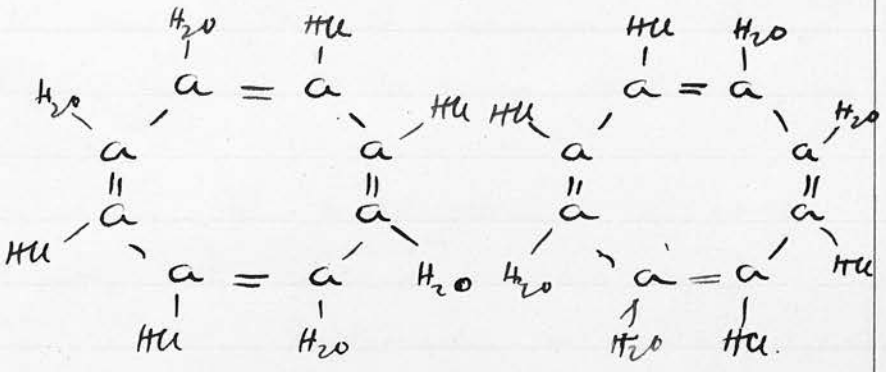
It has been said that the resulting peptone is heavier than the original albumen, weight for weight. Might not that be due to the combination with HCl which I have shown? If the peptone thus made be well washed with alcohol all the acid can be removed, if not so washed it is that much the heavier.

The process of peptonisation of albumen and globulin, however, is looked upon by some as a combination of hydration, with a simplification of the molecule. The process would be something like this, if the suppositions of HCl are remembered.

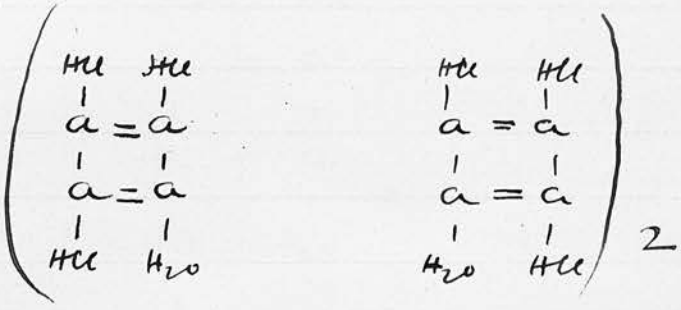




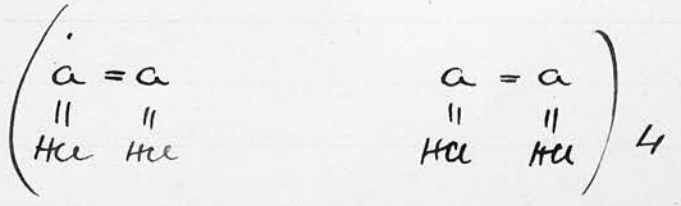
Hetero Albumose



Proto Albumose



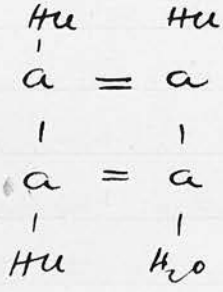
Peptone



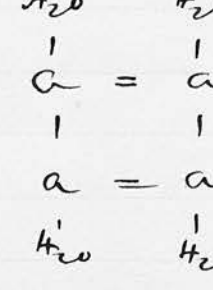
This scheme of course represents the different proteids as they are formed with the hydrochloric acid attached. The hydrochloric acid may be removed by washing with water the proteid itself being partly dissolved, or in some cases wholly. Molecules of water may take the place of the HCl removed. If the acid be removed with alcohol, the proteid is coagulated, that is, (to carry out the scheme), its form is altered by removal of the acid and from inability for molecules of water to re-

place the acid. This is a permanent change in the higher members of the series, temporary in the lower.

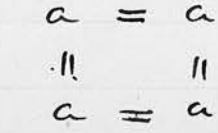
The changes in proto-albumose might be as follows, the different formulæ being when 1. Just made from gastric digestion



2. Dissolved in water; after washing.



3. Coagulated or precipitated with alcohol.



For these changes then, as far as regards peptic digestion, pure HCl in solution is required, as well as HCl which has previously combined.

To return to the first representations of the albumen molecule, I have represented them as consisting of eight, or multiples of eight, primary

molecules simply for convenience in dividing into the simpler molecules, and because these numbers agree with those of the combined HCl.

The peptone molecule consisting of only two (or multiples of two) of these primary molecules can be split up further by the pancreatic digestion into lower bodies, which, however, have molecules with differently arranged atoms.

Drechsel (loc. cit.) found from analysis of a salt, or chemical combination, of magnesium and globulin that the atomic weight of the proteid might either be 1496, or, just about its double, 2757.

In my first scheme I suppose it to be 1496., in my second 2757 the percentages of HCl as worked out are then, in the second,

Albumen	–
Acid albumen	7·9%
Hetero albumose	10·59%
Proto albumose	15·87%
Peptone.	21·1%

But I pointed out in my investigations above (p 241) that the amount of HCl combining with the proteid seems to vary with the proportion of HCl present. To account for this and yet let it coincide with my schemes as above, one has only to suppose that the

stronger solutions of acid can take the place of more molecules of water than the weaker ones.

For instance in the case of acid albumen, that is, 1 primary albumen molecule, with at least 12 molecules of H_2O attached, a weak solution of HCl would not be able to replace more than 6 molecules of water, — probably if it replaced less the albumen would not reach the stage of acid albumen, but be simply an albumen, with some acid attached, still coagulable on boiling, —— while a stronger solution might replace eight molecules of water at once, without being able, in the absence of pepsine to split it up further into simpler forms.

In the presence of pepsine, however, whenever the acid albumen has had 6 molecules of water replaced by HCl, sufficient energy is generated by the further action of the remaining per HCl to split up the molecule into a simpler one. This action of the hydrochloric acid in replacing more molecules of water being a sufficient cause, — with the aid of pepsine, — for the splitting. Now of course the simpler molecule has, in proportion to its molecular size, a greater percentage of hydrochloric acid combined.

In this way Hydrochloric acid is used up in Gastric digestion.

But it is only "used up," in the sense of conversion from the free to the combined state, no chlorine is lost. The acid thus combined is either absorbed with the proteid, I have shown that it can diffuse when attached to peptones, or converted into chlorides of Sodium etc in the duodenum.

Some hydrochloric acid is, of course, lost in the stomach from the formation of chlorides from the salts of the food.

No hydrochloric acid is lost or used up, that is split up, in the simple digestion of proteids, all can be recovered.

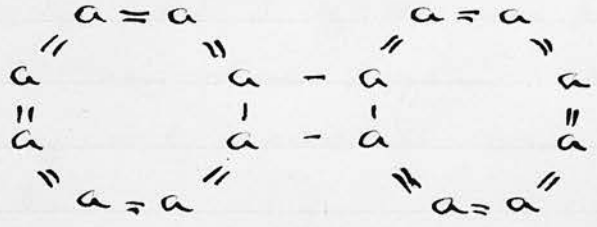
Other acids combine with proteids, and combining are able to split up the molecules, but this property only belongs to them to a comparatively small degree; they do not seize on the proteid molecule with sufficient avidity to give rise to the energy required to dismember it. Hydrochloric acid possesses the requisite avidity.

To put the matter, then, finally in a few words, I believe that each proteid molecule has a certain affinity for hydrochloric acid, that when the molecule is fully saturated with HCl, — pepsine being present — and there still be some free HCl left, the molecule breaks up into simpler molecules, which have a greater

affinity for the acid. And so the process goes on.

Two more points present themselves for consideration. One is the greater resistance to digestion offered by coagulated albumen as compared with soluble albumen. The other is the question of the hemi- and anti-albumoses and peptones as taught by Meissner and corroborated by Chittenden and Kühne.

First with regard to the coagulated albumen. To call my theoretical scheme again into evidence we find the formula for coagulated albumen as something of this nature



Any water there may be present being combined to the large molecule as a whole, not to the primary or simple molecules. In such a case, of course, the hydrochloric acid has a harder task, instead of simply having to replace water molecules, it must link itself on to the primary molecules themselves. The hand which stretched out before to keep hold of the water molecule, now clasps a neighbour

proteid molecule ; these molecules are therefore more closely bound together.

With regard to the Hemi and Anti products of digestion it is possible that when a molecule splits, it forms a hemi and an anti compound, the hemi can be further split up by the action of HCl and pepsine, the anti is not changed until it reach the duodenum.

The probable difference between them will be molecular, that is, changes in the primary molecules, which prevent further additions of HCl to them, will be present.

In all probability hemi- and anti- compounds are isomeric.

When a large compound molecule of albumen is acted on by HCl and pepsine, one part only may become peptone other and intervening anti- products remaining.

So

Albumen. (16a)

Hemi-heteo-albumose 8a — Anti-heteo-albumose 8a

Hemi-deutero albumose 4a — Anti-deutero-albumose 4a.

Hemi peptone 2a — Anti-peptone. 2a

"a" as before signifying the primary molecules.

Acid albumin I have missed out being only a transitional stage between albumen and the albumoses.

Classification of Proteids.

From a consideration of the proportion of HCl which combines with the different proteids, their behaviour as to diffusion, and in the presence of neutral salts I would classify them as follows, the order being from the compound to the simpler compounds.

1. Albumin.
2. Acid albumin (Syntonin)
3. Hetero albumose
4. Proto albumose
5. Deutero albumose
6. Peptone.

Dysalbumose, arguing from its slight affinity for HCl as compared with the other albumoses is probably a form of a more complex proteid.

Globulin splits up in the same way through with some slight differences, see p. .

1. Globulin
2. Acid globulin.
3. Hetero - globulose
4. Proto - globulose
5. Deutero - globulose
6. Peptone.

The simpler molecules thus formed and absorbed are built up again by cell activity into the complex forms and thus enter the blood stream.

This action has been shown to take place in the walls of the stomach and intestines.

To me the formation of dysalbumose from proto - or heteo - albumose is an analogous phenomenon.

Chapter II.

Classification of Stomach disorders.

I would divide diseases of the stomach into three broad classes, according as there is

1. Hyperacidity
2. Hypo-acidity
3. Normal acidity, present in the contents.

Richet, Hayem and Winter, etc, classify dyspepsias into hyper-, hypo-, and apepsia, grounding their division on the acidity present.

I. Hyperacidity

This may be;—

1. From an increased quantity of HCl present, free or combined.
2. From increase in organic acids.
3. From over secretion of HCl, that is secretion of HCl between meal times and during the night when there is no food in the stomach.

1. Increased HCl present.

True acid dyspepsia, the increase of acid present causing delay in digestion, with pain during it, is often present in cases with symptoms of Gastric ulcer or hæmorrhagic erosions, indeed it may be the cause of such conditions.

The only occasion on which this acid dyspepsia is found with malignant disease of the stomach, is when the cancer has occurred after and immediately following on a gastric ulcer. (This opinion I have heard expressed in Berlin by Ewald and Rosenheim.)

2. Increased acidity due to organic acids chiefly.

This is a more common form and occurs under most conditions, which allow of fermentation.

The commonest acid found is lactic, this is easily accounted for by the number of organisms found in the stomach which produce a lactic acid fermentation.

Then acetic acid, often found in cases of anaemia.

Butyric acid is seldom present in quantity.

Dilatation of stomach from any cause, atrophy of the walls, degeneration of the nervous plexuses (Jürgens 82), pyloric stricture, simple or malignant may allow stasis of the contents and consequent fermentation.

Deficient HCl may produce excessive acidity, from unchecked fermentation.

3. From oversecretion of HCl.

This is a rarer form, often found in neurotic irritative dyspepsias.

Washing out the stomach before breakfast reveals the presence of a considerable quantity of free HCl. This form is often combined with the first, great acidity, chiefly chlorine, appearing after meals.

Hyperacidity is a relative term; the acidity varying with the time after food, the character of the food, and with the individual.

The normal acidity, as usually given, is, of course, only a mean. What is hyperacidity to one individual, is normal — ceteris paribus — to another. An acidity, which will cause acute pain in one, does not trouble another.

Hyperacidity, chiefly from combined HCl, should be carefully distinguished from that due to free HCl or to free or combined organic acids.

So, for instance, the high degree of acidity attained after a public dinner is chiefly combined hydrochloric acid, and the frequent dis comfort which follows is due not to the hyperacidity but to the want of more free HCl for digestion and breaking up of the proteids.

Again the occurrence of heartburn after

even a small quantity of farinaceous food is not due to too much, but too little HCl. This form is seen frequently in females and should not be treated with alkalies.

II

Hypoacidity.

1. Atonic dyspepsia.
2. Chronic wasting diseases.
3. Malignant disease of the Stomach.
4. Acute gastritis.

1. Atonic dyspepsia.

Under this head might be classed disorders rising from various different causes. It includes the dyspepsias caused by anaemia, neurotic causes, as hysteria, neurasthenia, or simple nervous dyspepsia, want of exercise and constipation, and similar complaints. A simple atonic dyspepsia depending on a purely atrophic change of the mucous membrane of the stomach, or from a simple diminution in the HCl secreted may occur but commonly some further cause will be found on close examination.

In all these cases the percentage of HCl

is low and organic acids are present in greater or less quantities. In fact Atonic dyspepsia might be classed under the three groups, hyper —, hypo — and normal acidity, the constant factor being the low percentage of HCl present, the varying factor the quantity of the organic acids.

2. During the course of chronic diseases.

In phthisis and other wasting diseases the acidity of the gastric juice is decreased, as might be expected, a priori.

3. Malignant disease of the stomach.

This is no longer a "quaestio vexata", it has been proved over and over again that the quantity of acid in the stomachs, which are the site of malignant disease, is below the mean, and that per HCl is generally absent.

I have mentioned above (p 167) my opinion of this matter and recommended the testing of the contents after a purely amylaceous or farinaceous meal. It has been noted that cancer of the walls of the stomach has often no effect on the acidity, contrary to the conditions observed if the site be at either of the orifices.

Cancer of the walls or curvatures of the Stomach is frequently in the form of non-ulcerating plates, spread out in the substance of the wall, the French cancer "en Cuirasse."

The discharge from an ulcerating cancerous growth is partly blood, partly cells and debris, and partly serum. These substances contain large quantities of proteid bodies.

Hydrochloric acid combines with proteids.

Probably, then, absence of free HCl occurs in the majority of ulcerating malignant growths, while it may be present in cases in which the growths have not reached that stage.

It is also probable that, in all cases of cancer of the Stomach whether fungating, ulcerating or not, the total HCl secreted is below the mean. The patient in fact is suffering from a chronic wasting disease. This view is strengthened by the fact that cancerous tumours in other parts of the body, as in the liver, (without involving the Stomach) cause a diminution of acidity, or rather of the acidity due to HCl.

In all these cases of course increased acidity may be present from fermentation.

4. Acute Gastritis, acute catarrh of the stomach.

In this case also there is deficiency or absence of free HCl, the total amount too of HCl secreted being small. On the other hand there may be increased acidity from Lactic or the fatty acids.

III.

Dyspepsias in which there is the normal amount of acid present in the stomach contents.

1. Dyspepsias from liver disturbance.
2. Nervous dyspepsia.

As noted above the difference between a case of gastric ulcer and of dyspepsia with congestion of the liver often consists, to all appearance, merely in the amount of acidity obtainable from the contents of the stomach. In gastric ulcer there is always a degree of hyperacidity, in congestion of the liver the acidity is often normal, seldom much heightened but may be diminished.

The symptoms common to both are severe pain, vomiting, it may be of blood, melaena etc.

In cases of nervous dyspepsia the acidity often is of normal amount, but the nerves of the stomach walls are hyperaesthetic. Stimulated by the acidity they cause pain and nausea, and vomiting.

Sometimes when the nausea and pain be severe the sufferer himself brings on vomiting.

In this form the stomach can do its work but is not allowed to.

Chapter III.

The Treatment of Dyspepsias.
Based on the foregoing studies.

I will divide the treatment indicated into three divisions, corresponding to the three classes of Dyspepsias.

I. Treatment of Hyperacidity.

a. Increased hydrochloric acid present.

After establishing the nature of the complaint, by withdrawing some of the stomach contents if necessary, and after investigating the causes, one must be guided in treatment by the local conditions. If there is a gastric ulcer present, rectal feeding, either entirely, or in addition to spoonfuls of milk by the mouth, is indicated, especially if the case be severe. A slight case with little or no haematemesis or melaena may do well on rest and a purely milk diet.

Great pain at different times, especially in the evening or during the night may be relieved by some pure proteid in an easily digested form, such as powdered beef, which can be given rubbed up in a little milk. If this subdues or mitigates the pain it is preferable to the ordinary remedies, as some form of opium, bismuth etc.

Although this protein may increase the total acidity, it diminishes the free acidity.

It is the free HCl which causes the severe pain in such cases. By combining it with protein we render it partially inert and we nourish the patient.

All patients cannot stand this.

I would never hesitate to wash out the stomach of a patient suffering from Gastric ulcer, unless she were very weak. The danger of the soft india rubber tube causing perforation, is, with due care, infinitesimal.

In the chronic forms of gastric ulcer with long continued acidity, a weak solution of Nitrate of Silver, ½ gr to 1 gr to the oz, often helps the cure of the ulcer. The German authors recommend this procedure.

In treating the cause of the increased acidity we are confronted with a more difficult problem. The cause of the increased secretion of HCl in such cases is obscure. In cases of anaemia the state of the blood requires attention. In the nervous cases, sedatives. Alkalies given to immediately check the acidity do little good, except to soothe the irritated Gastric membrane. Decrease of the meals taken with the food may be persevered with for a considerable period. With regard to the diet, all food

consisting chiefly of carbohydrate material should be avoided. Milk and other easily assimilable and non-irritating proteids, esp. if in a state of fine division may be given. They enable the excess of free acid to combine.

b. Excess of the Organic acids

As this hyperacidity generally occurs, owing to the presence of hypoacidity, (deficient HCl plus increased fatty acids,) the treatment necessary is very different from that of the foregoing.

In patients with dilated stomachs, who suffer from this form of dyspepsia, forming indeed the major portion, alkalies and their bile do more harm than good.

Regular and constant lavage is the best method of removing the fermenting masses. The patient soon becoming content with the process, his relief being so great.

Then, or along with the last, he should be given some HCl either alone, or with some bitter-hydrochloric acid. The HCl acts both as a digestive and as an antiseptic.

If this is not tolerated, or it is advisable to clear the stomach of fermentation by other means, a powder with Bismuth, charcoal

(animal) thymol, eucalyptus or hyposulphate of Soda, with a drop or two of oil of peppermint or of cloves may be substituted.

In washing out such a stomach it is amply sufficient to do so by means of pure warm water. Antiseptics as thymol, or permanganate of Potash may be used, but as the primary fault lies in the usually deficient HCl, the Bacteria swallowed during the next meal can multiply exceedingly. The great thing is to wash the stomach out thoroughly, until the returning water is pure. Do this regularly each day, preferably in the morning as it allows the patient a better sleep, and at the same time attempt to treat the underlying cause.

A tonic may be also given to restore the general health as far as possible, iron, strychnia, arsenic etc if they can be borne.

In cases of dilated stomach with fermentation in which the primary cause is stricture of the pylorus, regular lavage is of use only when the stricture is of a simple character. If malignant little can be done to prevent the pain etc beyond the usual narcotics. In addition to washing out in cases of simple stricture of the pylorus, antiseptics are chiefly indicated, with perhaps Iodide of Potassium, or, as Dr Muirhead has recommended small doses of Mercury, the Green

Iodide answers best, made up in a pill with Carbolic acid.

Excess of acetic acid, occurring often in anaemic patients and also in others from no obvious cause, is best treated by attention to the general health and by the exhibition of antiseptics.

Hyposulphite of Soda is useful here.

c. Over secretion of HCl.

A very troublesome form of dyspepsia to treat. The pain which is so often complained of, most frequently during the night, when the stomach is empty is relieved best by food. A drink of milk and a piece of bread spread with the powdered beef, mentioned before, and a little butter, if taken when the pain is severe acts as a charm and facilitates sleep. Indeed in many of these dyspepsias some food, to be taken during the night if the patient be awake, is of great service in promoting sleep and easing any pain.

Alkaline mixtures are here of little service. They afford temporary relief, but really call on the stomach for more work. The more alkaline the contents of the stomach are the more acid is secreted. What is wanted, is to try and get the stomach glands out of the habit of secreting so much.

This will not be achieved by giving it alkalies to neutralise. The Saliva is alkaline and probably incites the stomach glands to more work. The chyme is acid and, in like manner, stimulates the duodenal and pancreatic secretion. While the contents of the small intestine become acid again, and thus excites the cells of the large intestine.

Soothing drugs as Bismuth and Cerium, and bland easily digested foods, principally of the proteid class are indicated.

Strive to soothe the too easily excited HCl cells of the stomach walls.

With regard to the treatment of hyperacidity generally, the indications are, first to render the excess of acid incapable of giving pain, secondly to remove the cause of the superfluity.

If the excess of acid be due to HCl proteids are necessary, if from organic acids, more HCl will probably be required.

II. Hyperacidity, its Treatment.

a. Atonic dyspepsias

In all members of this class the amount of HCl present is below normal, although the total acidity may or may not be above the mean.

The diet has to be strictly regulated from the first. In the beginning all food greasily cooked must be forbidden and, as far as possible, all the roots, potatoes, turnips etc.

The lighter proteids are the best, white flesh, fish and milk, while leeks, cauliflower, spinach, are allowable, with a little pepsin if it can be borne. If there is a previous history of alcoholism, alcohol should be avoided, if not a small quantity will help digestion either as beer or claret.

Acidum Hydrochloricum Dilutum in doses of from XV to XX minims is extremely useful, and, as I have found, useful from the first. Some have deprecated the use of this remedy early in such dyspepsias, arguing that it is wrong to do for the stomach what it should be able to do for itself, and advising the stimulation of its walls and nerves. To me it seems more reasonable

to help the organ to do the work it is manifestly unable to cope with, and, while doing so, to endeavour to restore the viscus to its natural vigour.

The following formula I find acts very well,

℞

Acidi Hydrochlor. Dil	℥ij
Acidi nitro hydrochlor Dil	℥iv
Pepsinæ Porci	℈ij.
Glycerini	℥vi
Syrupi limonis	℥ij
vel Saccharini et	gr ½
Essentiæ limonis	♏ xviii
(U.S.P.)	
Aquam ad	℥vi

Sig. A teaspoonful (4ml) for a dose.

The nitro hydrochloric acid and the pepsine need not be included unless wished. The saccharine and essence of lemon may be used if sugar is not advisable.

Combined with aërated water it forms a pleasant enough "after dinner" draught, better than most of the "after dinner" pills.

The Pepsine is not necessary, but can do no harm and may help the digestion.

Quite as important, however, is the careful regulation of the bowels, and of the urinary functions. While regular exercise, or some active employment are better than much medicine. I believe also in increasing the salt taken with the food.

6. Malignant disease of the Stomach.

Although the acidity in such cases is below normal and free HCl frequently absent, yet the stomach gets on fairly well with regard to digestion in many of them.

Of course I can add little or nothing to the routine treatment in such cases.

5. Acute Gastritis

Here with diminished HCl and great irritability of the stomach walls a combination of a weak solution of HCl and a very small quantity of cocaine after a light meal, of milk or white meat has a wonderful effect for the moment.

The cause must be rectified, alcohol stopped if it is due to this. If very irritable, peptonised foods find an application.

Locally Bismuth also may be serviceable

The chief indication is to give the stomach walls, the cells and nerves, rest either by giving them nothing to do, or at least very little work.

One method of applying Bismuth to the walls which I have seen of service is as follows. A considerable quantity of the Oxide or Subnitrate is stirred up in a pint of tepid water. This is introduced into the stomach through a stomach tube. After about 10 minutes the water is siphoned off again. The Bismuth being heavy settles in the stomach & coats the walls, the water is drawn off almost pure.

c. Dyspepsia with normal acidity.

The treatment for such cases is indicated above on page 204 et seq. The less medicine such cases get the better. Exercise, fresh air, free action of the emunctories, with a carefully regulated diet.

If the liver be out of order, a small dose of calomel to start with, followed by some bitter hydrochloric acid and Succus Taraxaci may be required.

General Treatment.

Lavage.

Of late much has been written on this subject. Especially with regard to chronic gastric affections has it proved of service.

I need not say more about it, it has been tried and found useful, and, I am glad to say, it is receiving more and more support in this country.

The application of electricity to the stomach walls topically however merits a word. Given for dilatation of the stomach I have seen little benefit follow. At first perhaps there is some feeling of relief, but any good effect soon disappears.

I found no difficulty in passing the stomach tube with a moderately flexible metal electrode in it. The pharyngeal reflex has, however, to be more deeply annulled with cocaine solution, as the stiffer tube causes more irritation.

Appendix

Since penning the above some further work has been done on the subject.

Felix (Bonn has published a dissertation on the action of artificial gastric juice on Acetic and Lactic fermentation (Strassburg.) In this work he demonstrates the inhibitory action of the HCl. No note is taken however of the combined acidity.

M. Ch. (Intejean contributes an interesting article on gastric digestion, entitled. "Sur le suc gastrique et sur la digestion peptique de l'albumine" (Archives de Phys. 1892 No 2. p 259.).

Professor Salkowski adds to his former paper, written in conjunction with Iwasawa and criticised adversely by Rosenheim and Hoffmann, a further contribution, "Ueber die Bindung der Salzsäure durch Amido-säuren." (Virchows Archiv Bd 127 Heft 2. s 501.)

In this he retracts his former statement that the presence of Leucin and Glycocoll in artificial gastric juice does not hinder digestion and confesses that it does so to a small extent, but not to such a degree as Rosenheim and Hoffmann allege.

In the foregoing pages I have not mentioned Ewald's Salol test, Klemperer's oil test, or Günzburg's Solution of Potash test for proving the absorptive power and digestive power of the stomach juice, partly because I have not had much experience in these, partly because I think them unnecessary. Two papers on these tests have appeared lately, in the Practitioner for March and April; and in the Correspondenz-blatt für Schweizer Aerzte, Heft 3, 1891.

A discussion, also, has lately been going on in the columns of the Archiv edited by Pflüger between Wagner of St Petersburg on the one hand, and Friedheim & Leo on the other concerning the merits of the "methode Salzsäure bestimmung mittelst Calcium Carbonate," as brought forward by the last named. At present the results of the controversy are of little value.

A full account of Ewald's Salol test has just come to hand in a thesis published by F. Ochmen "Ueber dein Nachweis ~~Nachweisung des Künstlichen Magensaftes~~ der krankhaften Störungen des Magens mittelst Salol" (Giessen 1891). It advances little new.