ART. X.—*History of a case in which a fluid periodically ejected from the Stomach contained Vegetable Organisms of an undescribed form.* By JOHN GOODSIR, Conservator of the Museum of the Royal College of Surgeons in Edinburgh; *with a Chemical Analysis of the Fluid*, by GEORGE WILSON, M.D., Lecturer on Chemistry in Edinburgh.

MR ———, aged 19, consulted me about a stomach complaint, under which he had been labouring for four months, and which had more or less resisted every attempt made for its removal. He informed me that he considered it to be water-brash; that it attacked him on awakening in the morning with a feeling of distension of the stomach; that, without any effort of vomiting, a quantity of fluid, varying in volume from two-thirds to a whole wash-hand basonful, passed up from his stomach; that after this he was quite relieved, and experienced no further inconvenience till the evening of the same day, when, without decided distension, sounds as of a fluid boiling or bubbling, and proceeding from the region of his stomach, were perceptible to himself and to those around him; that he slept well enough, but was generally attacked in the usual manner next morning. Such was my patient's own account of his case.

On examining more particularly into the symptoms, I could ascertain nothing positive. His tongue and pulse were natural; he had no headach, nausea, or thirst; no tumour could be detected in the epigastrium, and no pain on pressure was complained of in the region of the stomach. The bowels were moved daily, and the stools were normal. His appetite was not affected, and the usual articles of diet appeared to agree with him. He was thin, but had a good complexion, and his flesh was firm. He stated that he had formerly been very fat, but that this had left him before the accession of his stomach complaint. I was informed that one of his testicles had never descended beyond the groin.

Of the various remedies which had been tried for his relief, prussic acid appeared upon the whole to have exercised the greatest influence over the disease, preventing the attacks with considerable certainty for several days in succession.

Being unable to make up my mind as to the exact nature of the case, but conceiving it probable that there might be ulceration or some other organic lesion of the stomach, I ordered croton oil, frictions of the epigastric region, and the internal remedies to be discontinued. I also requested that the ejected fluid might be preserved for my inspection.

Next day I found that he had had an attack in the morning as usual. No new symptoms presented themselves.

On examining the ejected fluid, I was struck with the truth of what had been stated to me, that it smelt like fermenting worts, with a faint acid odour. It appeared, after having stood for a few hours, moderately transparent, and of a light brown colour. It had deposited in the bottom of the bason a quantity of a ropy matter, of a granular appearance; and on the surface was a mass of froth like the head of a pot of porter.

By a consideration of all the circumstances of the case, I was now induced to conceive it possible that this and other cases of similar stomach complaints might depend on fermentation of the contents of the organ. Such a fermentation might, I presumed, be primary, that is, induced by the chemical constitution and relative conditions of the contents of the stomach; or it might be secondary, that is, induced by circumstances in the condition of the organ standing in the relations of primary causes of the whole complaint. But, whatever might be supposed to be the cause of the presumed fermentation, it appeared to me highly probable, that, if it had really taken place, it would be indicated by the remains of ferment-vegetables in the ejected fluid.

In the meantime, till I had examined the fluid more minutely, I merely regulated my patient's diet. Animal food was recommended; vegetables and malt liquors were forbidden, and a little brandy was ordered in water for drink.

I now proceeded to examine the fluid ejected from the stomach, and in proceeding to do so, I expected, if I found any vegetable form at all, to see some of the globular or moniliform algæ, which it now appears pretty certain are concomitants of certain of the fermentations. What was my astonishment then to find, in the first drop I examined, not the vegetables I was led to expect, but numerous individuals of a form, with allies of which the zoologist is familiar! Drop after drop exhibited the same specific form, with a precision which convinced me that I had now to deal with an organism which, whether animal or vegetable, was closely allied to certain genera of Bacillariæ, and much more closely to the genus Gonium among the Volvocinæ.

Before I proceed with the history of the case, or with the description of the organism which characterized it, it may be well to state, that, in addition to a few fragments and shreds of undigested food, the ejected fluid presented the following microscopic elements.

1*st*, Fecula cells, globular, ovoidal, and kidney-shaped, with well-marked hila of attachment. Some of these cells were transparent and empty, others were full of starch granules, and reacted powerfully with iodine. These cells were at first presumed, and were afterwards proved by comparison, to be nothing more than the remains of wheaten bread.

2d, Much larger, more irregular, flaccid, ruptured, or half emptied cells, full of granular matter, which reacted with iodine, and were recognized as fecula cells of the potato, as they appear after boiling.

3d, Minute shreds of muscular fibre, cellular tissue, and fat cells, remains of the food.

4th, Globules or globular masses, from 500 to 100 of an inch in diameter, apparently oily, and presumed, although as to this no inquiries were instituted, to be some form of the chyme.

5th, Occasionally, but rarely, portions of bran, consisting of the perisperm of the wheat, recognizable by its internal surface presenting irregular-sized, ovoidal or hexagonal shallow foveæ, with included fecula cells.

6th, The organisms themselves, which I at once recognized as belonging to the vegetable kingdom, and considered either as the cause of the symptoms in my patient's case, or at least as very remarkable and important concomitants.

I may state that these organisms could not have been swallowed in the water used for drink, as the water employed by the family for that purpose was regularly passed through a stone filter. I used every precaution also in ascertaining that they could not have been introduced along with any article of diet, and in satisfying myself that they were not portions of any animal or vegetable tissue.

I now recommended a return to the use of the prussic acid. I ascertained that it exercised a decided influence over the disease. After some time, however, I became satisfied that it acted more by enabling the stomach to retain its contents, than by any direct influence in preventing the formation of the fluid itself.

The case proceeded for about a fortnight without any change in the symptoms, the prussic acid being regularly taken at bed-time, with the effect of putting off the attacks occasionally for a day or two at a time.

I now determined to give creosote, from a belief that it would not only act, as the prussic acid had done, in preventing the ejection of the fluid, but that it would also put a stop to its formation. This I conceived it would do, whether the disease arose from a simple fermentation of the contents of the stomach, or from the development of the organisms as a primary cause.

A drop of creosote was ordered every night at bed-time. Supper was forbidden; a very light dinner of animal food was recommended, and breakfast indicated as the principal meal. Cessation of his somewhat sedentary habits, active country exercise on foot and horseback, and attention to the bowels were insisted upon.

A decided improvement now took place. The attacks, instead of recurring almost every morning, now took place only on the

fifth or sixth morning, and latterly at intervals of eight or ten days. The quantity of fluid ejected also diminished in quantity, not exeeding six or eight ounces.

The attacks again increased slightly in frequency, and in quantity of fluid ejected, but this was at once controlled by a gradual increase of the dose to four drops at bed-time. It also appeared advisable to divide the dose, so as to take two drops in the forenoon, and three or four about one hour and a-half after dinner, so as to stop the formation of the fluid. This effect my patient felt satisfied the creosote produced, as the bubbling or crackling sensation in the stomach usually ceased after taking his dose.

The bowels were now acted upon rather smartly, so as to promote the action downwards from the stomach.

At the present date I have it not in my power to state that the complaint is removed, although the attacks are much less frequent, and the quantity of fluid diminished. The creosote, however, has a most decided control over it, and will, I am inclined to believe, ultimately cure it. The disease, indeed, may depend on the patient's time of life, and on the peculiarity of his constitution, and may gradually disappear even without medicine, as a consequence of increased corporeal vigour.

The Structure, mode of reproduction, and development of Sarcina ventriculi, the parasite detected in the ejected fluid.—The following description is drawn up from examination of the ejected fluid for a period of nearly two months.

In every instance the organisms presented themselves in the form of square or slightly oblong plates. The thickness of an individual was about one-eighth of the length of one of its sides. Under a moderate power the sides and angles appeared straight and well-defined; but under deeper glasses, the angles were rounded, and the sides sinuous; appearances which resulted from the uncompressed forms of the component cells in their particular directions. The flat surfaces were divided into four secondary squares by two rectilinear transparent spaces, which, passing from side to side, intersected one another in the centre like two cross garden walks.

Each of the four secondary squares was again divided by similarly arranged, but more feebly developed spaces, into the four ternary squares.

The sixteen ternary squares thus constituted, when examined with deeper powers, were seen to consist each of four cells, which were not separated by transparent spaces, but simply by dissepiments formed by the conjunction of the walls of contiguous cells.

These sixty-four cells of which the organism consisted did not present in perfect individuals distinct nuclei; although in certain

instances appearances presented themselves, having relation to the reproduction of the organism, and falling to be described in another part of the paper.

The individual organisms were transparent and slightly yellow or brown. When carefully examined under favourable circumstances the cell-walls appeared rigid, and could be perceived passing from one flat surface to the other as dissepiments. These dissepiments, as well as the transparent spaces, were from compression of contiguity rectilinear, and all the angles right angles; but the bounding cells bulged somewhat irregularly on the edges of the organism, by reason of the freedom from pressure.

These circumstances gave the whole organism the appearance of a wool-pack, or of a soft bundle bound with cord, crossing it four times at right angles, and at equal distances.

From these very striking peculiarities of form, I propose for it the generic term SARCINA.*

Perfect individual SARCINÆ, of the species now under consideration, vary from 800 to 1000 of an inch linear, along each of their sides. They are, as has been stated, slightly brown or yellow under a high power—under moderate glasses they appear dark, and are defined with difficulty on account of the frequent reflections of the light by the dissepiments. Iodine does not react with them, as with starch, but tinges them deep brown or yellow. They shrivel but slightly in alcohol. In nitric acid, even after boiling for some time, the sixteen ternary squares retain their relative position, but diminished and shrivelled, appearing like minute crystalline granules arranged in a square. So persistent are those arrangements of granules in boiling nitric acid, that I at one time suspected the existence of silicious loricæ, or isolated raphides, but as I could not detect the same forms or arrangements in the ashes of the evaporated and calcined fluid, I do not now believe in their existence.

This species of SARCINA, therefore, consists of sixteen four-celled frustules, imbedded in a square tablet of a transparent texture, as in the GONIUMS. The four-celled frustules correspond to the cells or globules; the tablet to the phycomater or gelatinous matrix of certain of the ULVACEÆ.

The generation of SARCINA is fissiparous, each individual dividing into four. This is proved by the following circumstances.

1*st*, Specimens are frequently met with which, instead of 16 ternary squares, and 64 ultimate cells, exhibit 64 ternary squares,

* SARCINULA would have been more appropriate, had not Lamarck already applied the term to a genus of polyps.

and 256 ultimate cells. Such specimens are not, I conceive, to be considered as individuals, in as much as, 1*st*, Their four component squares are very loosely connected together; 2*d*, One or two of the squares may be awanting, or two or more of these may remain attached by the angles,—an arrangement never presented in the primary squares themselves.

2*d*, Large specimens are occasionally met with, which have most of the characters of composite individuals, that is, of individuals about to divide into four. Such specimens do not present 256, but only 64 ultimate cells, and these, exhibiting appearances not easily defined, but apparently consisting of four opaque spots, as if each cell were about to be divided into four parts, or were in the act of producing within itself four new cells.

Such appearances rendered it difficult to say whether certain specimens were simple individuals or composite—single adults, or adults about to divide each into four young ones.

I therefore conclude, that a perfect individual SARCINA consists of 64 ultimate cells, but that as soon as each of these again divides into, or produces four new cells, the individual becomes composite, and may forthwith divide into four young ones, each of these again to undergo the same quaternary division.

Such a mode of generation will account for what I frequently observed,—two, three, or four SARCINÆ attached by their angles only, as in the baccillarian genera. It also explains why I could never detect more than four so united. It may account for the circumstance that the SARCINÆ were found grouped as it were in colonies, in certain portions of the ropy fluid, some drops containing numbers of them, others none at all.

Such is the structure, mode of reproduction, and of development of this species SARCINA.

In tracing these out, it cannot but have been observed how beautiful is the symmetry of all the arrangements—how the parts of the individual are arranged in the square—how these parts increase in numbers in a geometrical progression—1, 4, 16, 64, 256,—and lastly, how the species propagates according to the same law, 4 in the first generation, 16 in the second, 64 in the third, 256 in the fourth, 1024 in the fifth, and so on with a rapidity peculiar to such a series of numbers.

Is SARCINA an animal or a vegetable? is it one of the infusorial Polygastrica, or a minute Alga? In order to give a satisfactory answer to this question, it becomes necessary to analyse the groups to which SARCINA is most closely allied.

Putting out of view for the present the FRAGILLARIÆ, DIATOMACIÆ, and other gonioid organisms, the animal or vegetable nature of which is yet a matter of doubt, I shall proceed to Mul-

ler's genus GONIUM, the genus of all others to which SARCINA has the greatest affinity.

The genus GONIUM consists of composite polygastric animalcules, each corpuscule of the whole animal having, according to Ehrenberg, the organization of a monad, oral appendages, visceral sacs, &c. Ehrenberg does not enumerate eye-points among the characters of the family to which the GONIUMS belong, (VOLVOCINÆ). Without coming to any decision as to whether the red points on certain species of GONIUM be really eye-points, or merely optical illusions,* I may state at once, that I am much inclined to believe, that the genus GONIUM, as at present constituted, contains both animal and vegetable species—the former characterized by oral appendages, voluntary motions, (eye-points?), the latter by their simple cellulo-globular formation. GONIUM PECTORALE, (*Pectoralina Hebraica*, B. St Vincent,) GONIUM PUNCTATUM, contrary to the opinion of Bory St Vincent and others, appear to be true composite animals.

But Ehrenberg has here, as in many other instances, decided for the animal nature of organisms in which even his experienced eye could not detect the characters of the family.

Such is the case with GONIUM HYALINUM, GONIUM GLAUCUM, and probably with GONIUM TRANQUILLUM.

These three species appear to consist merely of cells full of chlorophylle imbedded in the square plate which corresponds to the outer envelope of the NOSTOCHINÆ.

To such forms belongs SARCINA. It exhibits no mouths, no oral appendages, no visceral sacs, and its cells, instead of having the gelatinous appearance so familiar to the observer of the animal infusorials, are clear, transparent as if empty, and have that consistency of wall characteristic of vegetable structure.

Believing SARCINA to be a vegetable, I may state, in reference to its characters, that they are of a kind which distinguish it from all the gonioid plants at present known. It differs most essentially from PECTORALINA HEBRAICA of Bory St Vincent, which, as we have already stated, appears to be a true animal. It makes the nearest approach to GONIUM HYALINUM, which with GONIUM GLAUCUM and GONIUM TRANQUILLUM, even Ehrenberg himself seems inclined to hand over to the botanists under the generic term GONIDIUM.

The generic characters of SARCINA are to be found in the predominance of the constituent cells over the outer coat or lorica, in each frustule being four-celled, and in the entire freedom of these

* It may be well to state, that the red dots do not appear in all the species, and it is interesting to observe, that those species in which they have not been detected are the very species in which oral appendages apparently do not exist.

from all coloured contents. Of the specific characters of a single species much cannot be said.

I define the genus thus:

SARCINA. Plants coriaceous, transparent, consisting of sixteen or sixty-four four-celled square frustules, arranged parallel to one another in a square transparent matrix.

Species 1. SARCINA VENTRICULI, *mihi*. Frustules 16; colour light brown; transparent matrix very perceptible between the frustules, less so around the edges; size 800 to 1000 inch. Hab. the human stomach.

As soon as I had detected the SARCINA, I called upon my friend Dr George Wilson for an analysis of the fluid. The following is his report.

"The liquid sent me for examination was thick and viscid; by standing, it deposited a large quantity of ropy matter mixed with portions of undigested food, and when filtered through paper it had a pale brownish yellow colour, and was quite transparent. It still contained much animal matter in solution, becoming opaque and flocculent when boiled, and giving a very copious precipitate with infusion of galls. It also precipitated nitrate of silver densely, and when evaporated to dryness, and exposed to a full red heat in a platina crucible, left an ash containing much chloride of sodium. It had a peculiar acid odour, which all who have observed compare to that of sour beer; it reddened litmus powerfully and effervesced sharply with alkaline carbonates. These remarks and all that follow, apply without exception to portions of liquid ejected at various intervals during a period of four weeks.

To determine the nature of the acid which existed so abundantly in the ejected matter, a pint of the filtered liquid was distilled in a retort, till nine-tenths of the whole had passed over. The fluid in the receiver was colourless but opalescent, and a flocculent matter was diffused through it; it reddened litmus strongly, and gave, with nitrate of silver, a precipitate insoluble in nitric acid, and soluble in ammonia. The latter reaction seemed to point to the acid as the hydrochloric, but as the liquid had not the odour of that acid, and the presence of flocculent matter showed that substances not truly volatile, had been passing over with the vapour during distillation, I suspected that the precipitation of the silver-salt had resulted from chloride of sodium transferred from the liquid in the retort by a similar process of mere mechanical convection. To decide this point, a portion of the distilled fluid was evaporated to dryness in a porcelain capsule, and strongly heated; distilled water poured upon the residue precipitated nitrate of silver, indicating the presence of some fixed metallic

chloride.* To remove this, the liquid was filtered from the animal matter it held in suspension, and slowly distilled a second time in a capacious retort. The product of this distillation was colourless and transparent, and possessed a strong acid reaction, but gave not the slightest haze with nitrate of silver. It retained the vomit-smell, and along with it a faint acid odour, which was not perceptible to myself, but which others recognized, and pronounced to be that of vinegar.

To ascertain the nature of the acid, six ounces of the twice distilled liquid were neutralized with lime-water, and evaporated to dryness. The lime-salt was then transferred to a tube-retort, and distilled with sulphuric acid slightly diluted. A colourless liquid collected in the receiver, which was at once recognized by its odour to contain acetic acid. This experiment was very carefully repeated with four portions of liquid distilled from different specimens of the ejected matter; the result was the same with all, an acid liquid was procured, which all who smelled it pronounced to be acetic acid.

I was the more careful in repeating these trials, that Berzelius has shown that in the analysis of animal fluids, other volatile odorous acids may readily be mistaken for acetic acid. He particularly notices that lactic acid, accompanied by a chloride, may seem to be an acetate, when moistened with sulphuric acid; the sharp smell of the evolved hydrochloric acid passing for the peculiar odour of the acetic. Even so expert a chemist as Leopold Gmelin has been deceived in this way.† But the liquid from the stomach, the lime water, and the sulphuric acid, were all tested and found to contain no chloride, nor did the distilled liquid contain any; moreover, the evidence of the acid being the acetic, did not depend on the perception for a moment of a faint and fleeting odour, when the salt was moistened with sulphuric acid; a drachm of liquid was obtained by each distillation, so that the odour could be perceived and identified by many persons. In further trial of the acid, it was ascertained, that when digested in the cold on recently precipitated oxide of lead, it formed a soluble salt, having a sugary taste, and possessing an alkaline reaction. The acquire-

* Berzelius has particularly pointed out the difficulty of distilling viscid animal fluids in retorts, without the transference of non-volatile matters, which appear to be projected upwards by the bursting of the bubbles of vapour produced during tumultuous ebullition. Traité de Chimie, Tome vii. p. 616. Ed. 1832.

Liebig has likewise called the attention of chemists to the remarkable power which vapours possess, of carrying along with them portions of bodies (such as nitre, boracic acid, chloride of sodium), which in their solid form resist dissipation by very high temperatures. When such bodies are dissolved in water, its vapour, even when far below the boiling point, determines their volatilization along with itself. Organic Chemistry in its application to Agriculture, 1st Ed. p. 111.

† Berzelius, op. et loc. citat.

ment of the latter property, depending on the formation of a subsalt of lead, has been shown by Liebig to be distinctive of acetic acid.*

The proportion of acetic acid in the twice distilled fluid was ascertained in the usual way with the alkalimeter, by finding the quantity of carbonate of potass required to neutralize it. It was found by several trials, that, on an average, an ounce of the liquid neutralized 0.4 gr. of the carbonate; a quart (32 oz.) would therefore neutralize 12.8 gr. which correspond to 9 gr. of the hydrated (crystallizable) acetic acid $HO + C_4 H_3 O_3$.

The liquid remaining in the retort after the first distillation, was now examined and found still to be strongly acid. This property was traced in part to the presence of a small portion of free hydrochloric acid. The large amount of chloride of sodium which accompanied it made it difficult of detection; nor did I succeed in ascertaining its proportion. But I satisfied myself that it occurred only in small quantity by the following experiments. Some ounces of the filtered liquid, along with a portion of red oxide of lead, were placed in a flask provided with a bent tube dipping into a wine glass, containing a very weak infusion of blue cabbage. The flask was then heated till the liquid boiled, and, by the quantity of vapour sent through the infusion, made the latter boil also. The cabbage was reddened, but not perceptibly weakened in tint; whereas had free hydrochloric acid been present in any quantity, it must have been deprived of hydrogen by the metallic oxide and chlorine evolved. When the experiment was repeated, with the addition to the flask of a little sulphuric acid, the infusion was bleached in a few seconds. A similar experiment was made with the substitution of a solution of hydro-sulphuret of ammonia for the vegetable infusion, with a view to convert any evolved chlorine into muriate of ammonia. The hydro-sulphuret was then evaporated to dryness, and nitrate of silver added; a precipitate of sulphuret and chloride of silver fell, but when the latter was dissolved out by ammonia, its amount was found to be very small. Again, several ounces of the liquid from the stomach were boiled for some time with peroxide of manganese, and thereafter filtered. The filtered liquid was then tested for chloride of manganese, with caustic potash; a very slight precipitate of protoxide fell. As the quantity of hydrochloric acid discovered in this portion of the liquid was too small to explain its marked acidity, I made careful search for another acid, and soon detected the presence of one which was not volatile, but was destructible at high temperatures. Different processes were adopted for the isolation and purification of this acid, which was separated

* Graham's Elements of Chemistry, p. 785.

with much difficulty from the accompanying salts and animal matter. I state the results very briefly.

The concentrated liquid from the retort, which now possessed a dark brown colour and was very viscid, was evaporated on the water-bath till it ceased to lose weight. It formed a gummy mass, which remained moist after many hours exposure to a heat of 212°, and retained unimpaired the power of reddening litmus strongly. The mass was boiled with successive portions of alcohol of sp. gr. 0.880, so long as the latter acquired an acid reaction; the greater part of the animal matter remained undissolved, but the alcohol was coloured dark-brown. On evaporating this solution on the water-bath, a viscid matter was left, strongly acid to litmus, and possessing a saline taste occasioned by the chloride of sodium dissolved along with it. The alcoholic extract was boiled with successive portions of sulphuric ether, recently rectified from carbonate of potass, and ascertained to be quite neutral. By this treatment, the extract lost its acidity, which was transferred to the ether; but it required a large quantity of the latter to remove it entirely. The etherial solution was of a pale yellow colour, and had dissolved very little of the salts or animal matter. When the ether was vaporized on the water-bath, there remained a thick yellow liquid, reddening litmus strongly. It was kept for an hour at the temperature of 212° without drying up; it could be dissolved in water and evaporated to its original consistence many times in succession, without dissipation of the acid; but when left in its most concentrated state, it absorbed moisture from the air, and became more liquid. When exposed in a capsule to a naked flame, it darkened in colour, the animal matter became charred, and the whole was destroyed.

Leopold Gmelin and others have shown that when hydrochloric acid is accompanied by much animal matter, it may be entangled in it, so as to escape dissipation by heat. It will afterwards be shown, that the acid was certainly not the hydrochloric; but to obviate any objection which might be founded on this fact, several portions of the liquid were treated in the following way. Some ounces were concentrated by evaporation, and boiled on protoxide of lead, till the liquid had lost all acid reaction. By this treatment the hydrochloric acid should be converted into the insoluble chloride of lead. The liquid was filtered, decomposed by a current of sulphuretted hydrogen, boiled, and filtered a second time. It yielded a pale yellow fluid markedly acid, which was subsequently treated with alcohol and ether by the method already described. The liquid, after the second filtration, still precipitated nitrate of silver, for it contained all the chloride of sodium originally present. Although this was no real objection to the distinction of the acid from the hydrochloric, I was anxious to satisfy

myself that it could be procured quite free from chlorine. With this object in view, several ounces of the liquid were boiled with a portion of carefully prepared and crystallised sulphate of silver, till it ceased to give a precipitate with the nitrate of the same base. A current of sulphuretted hydrogen was then passed through the liquid, to precipitate the excess of sulphate necessarily added, after which it was boiled and filtered. It now contained free sulphuric acid, and sulphates instead of chlorides; it was digested on oxide of lead, until it lost all acid reaction, filtered from the sulphate of lead and excess of oxide, and submitted again to sulphuretted hydrogen, till a precipitate ceased to fall. After being boiled and filtered anew, it was evaporated on the water-bath, and digested with alcohol, which left the sulphates undissolved. The product of these operations, which contained no inorganic acid, reddened litmus strongly.

Other processes were followed, which need not be detailed; none of them yielded an acid quite free from animal matter, nor was it ever procured in large quantity; but it presented the same properties in whatever way obtained. I did not ascertain the solubility of the acid in ether, till the inquiry was nearly concluded, so that some of the experiments hereafter mentioned were made with the alcoholic solution, which was less pure.

The following properties were ascertained by repeated trials to belong to this acid. It was soluble in ether, alcohol, and water, was quite destitute of odour, and neither volatile nor crystallizable. When the aqueous solution was digested on phosphate of lime prepared from bones burned to whiteness, and freed from carbonate of lime by boiling with acetic acid, and subsequent protracted washing with water, it dissolved a large portion of the salt; and it acted in the same way on the recently precipitated phosphate. It formed a soluble salt with oxide of silver, which strikingly ditinguishes it from hydrochloric acid. It formed soluble salts likewise with oxide of lead, with potass, soda, ammonia, baryta, and lime; the last soluble also in alcohol. It sustained a heat of 300° without decomposition, but when the temperature was much elevated it inflamed along with the animal matter accompanying it, and suffered destruction. It was always found, however, that the animal matter gave way before it, for after charring had occurred to some extent, water still dissolved an acid from the mass.

On comparing these properties with the characters known to distinguish the organic acids of animal origin, they will be found to correspond closely with those of lactic acid, which accordingly I believe the acid I have been describing to be. Hydrated lactic acid ($HO + C_6 H_5 O_5$) is stated by Berzelius * and Liebig †

* Traité de Chimie, Tome vii. pp. 612—620.
† Turner's Chemistry, p. 996.

to constitute a colourless syrupy liquid, inodorous, uncrystallizable, and not volatile, but decomposed at a temperature of 480°. It forms soluble salts with all the metallic oxides, and dissolves a large quantity of phosphate of lime. There is no single decisive test of its presence, nor does it present any other marked characteristics which could be sought for in the acid under examination. One method there certainly is by which the identity of this acid with the lactic could have been ascertained, an ultimate analysis namely, and discovery of its atomic weight; but it was impossible to put this plan in practice. Nevertheless, I think the conclusion will be admitted that the acid was the lactic.

Three acids then were found in the liquid—hydrochloric, acetic, and lactic; the first was present in too small quantity to be considered a morbid product. So far as the organic acids are concerned, it is impossible to say whether their mere presence constitutes a morbid sign, for the statements on record concerning the normal acids of the stomach are very incomplete and unsatisfactory. Dr Prout found in the stomachs of the lower animals no acid but the hydrochloric.* Leuret and Lassaigne found only the lactic;† Schultz only the acetic;‡ Chevreul found only the lactic in the gastric juice of dog, and in the liquid brought up by an emetic from the stomach of a healthy man fasting.§ On the other hand, Gmelin found in the lower animals muriatic and acetic acids, and in the horse butyric acid.‖ Dunglison, who analysed the gastric juice from the stomach of St Martin the Canadian, whose case has been described by Dr Beaumont, found muriatic and acetic acids.¶ Dumas, in his Lectures on Organic Chemistry, delivered last summer, (1841,) stated the normal acids to be the muriatic and lactic.**

To perplex the inquiry still further, Gmelin admitted no distinction between lactic and acetic acid, or, at furthest, conceived the former to be the latter modified by adhering animal matter. Now that we know these acids to be quite distinct in composition and properties, the observations of Gmelin, otherwise so high an authority, lose much of their value.

In the preceding summary of conflicting opinions, it will be observed, that whilst some chemists contend for lactic, and others for acetic acid, as the normal organic acid of the gastric juice, no one professes to have found both acids in the same liquid, as was the case with that which I have analysed. One of these acids, then, was abnormal, but which? It would be useless attempting to decide this question by an appeal to the relative worth of the autho-

* Phil. Trans. 1824, p. 45. † Recherches Physiologiques et Chimiques, p. 115.
‡ Muller's Physiology, p. 564. § Leuret et Lassaigne, op. cit. p. 117.
‖ Recherches sur la Digestion, Vol. i. p. 166–67; Vol. ii. p. 317.
¶ Muller, op. and loc. cit.
** Manuscript notes kindly furnished by Mr Norton.

rities quoted ; it is not improbable that both acids are developed during healthy digestion. Lactic acid is so abundant, free or combined, in the milk, blood, urine, and other parts of the body, that its existence in the stomach is almost certain. As for acetic acid, it is a much rarer constituent of animal fluids, and there can be little doubt that lactic acid has often been mistaken for it.

In the meanwhile however, till new researches are made on this subject, neither acid can be considered by its mere presence as a morbid sign. I may, however, remark, that lactic acid has already been found by Dr Graves in the liquid vomited by a sufferer from dyspepsia ;* and MM. Boutron and E. Fremy, in a paper on the lactic fermentation, observe, " It is known that the liquids contained in the stomach can, in certain conditions, present a strongly acid reaction. Now, the analyses made on this subject demonstrate in these liquids the presence of lactic acid."†

One thing, however, is certain, and it is the main truth elicited by the analysis, viz. that the quantity of acetic acid found in this case was enormous. Although we have no account of the proportion discovered in the gastric juice or chyme, by those who maintain its presence there, it is certain that the quantity must be very small. Prout overlooked the presence of an organic acid altogether, and Gmelin, the great advocate of its existence, found only traces of it. But the quantity of liquid ejected at once by the patient, often amounted to more than two quarts, which would contain eighteen grains of acetic acid ; and the amount is rather understated, for some portions of the liquid were necessarily lost in the distillations, which, moreover, were never pushed to dryness.

I am not aware of any case on record corresponding to this ; but I forbear at present forming any opinion as to whether this remarkable development of acetic acid, and the occurrence of the curious organisms decribed by Mr Goodsir, were mutually dependent or merely coincident.

The liquid otherwise was not particularly examined as to its salts or animal matter."

Those who know the doubt which at present exists as to the acids which are found in the stomach in health and disease, will perceive the value of the foregoing analysis. Other questions arising out of the consideration of the case, as well as its future progress, will be taken up and recorded in future communications on healthy and morbid digestion—subjects with which Dr Wilson and I are at present engaged.

Plate VII. Fig. 2. Sarcina ventriculi in a perfect state.

Fig. 3. One of the four-celled frustules.

* Transactions of the Association of Fellows and Licentiates of the College of Physicians in Ireland, 1804, Vol. iv. Quoted in Tiedemann and Gmelin, Vol. i. p. 167.

† Annales de Chimie et de Physique, 3me serie, Tom. xii. 1841.