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THE CHEMICAL INVESTIGATION OF

GASTRIC AND INTESTINAL DISEASES

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THE CHEMICAL INVESTIGATION OF GASTRIC AND INTESTINAL DISEASES

BY THE AID OF TEST MEALS

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INTRODUCTION

MODERN Medicine has advanced along scientific lines, so that to-day the clinician is compelled to call Science to his aid in the investigation of disease. Just as the surgeon requires X-rays to elucidate certain problems, and bacteriological methods of investigation are imperative in the diagnosis of some diseases, so the physician, in treating diseases of the stomach and bowels, requires the aid of chemical analyses for making an accurate diagnosis. More especially is this the case in functional diseases in which there may be no physical signs, and in which the symptoms may be very misleading.

The methods of investigating diseases of the stomach and bowels are very numerous, and it is impossible in a book like the present to enter at all fully into the subject. We will, therefore, confine our attention for the most part to chemical methods which we have ourselves employed for some twelve years with more or less useful results. The results summed up in this work must not be regarded as conclusive, but merely as a preliminary to more careful chemical investigation of stomach and bowel diseases. We shall only cursorily mention microscopic appearances as these have not been especially investigated: and bacteriology we shall leave entirely alone, not because we under-rate its importance, but because its importance is so great that it ought only to be described by bacteriologists themselves.

It was originally intended to discuss more or less completely the views held by other observers, but as the work progressed, one found the results to be so numerous and so conflicting, that to deal with them at all would make a book far too unwieldy for practical use; it has, therefore, been our endeavour to keep the book within clinical limits, and to lay stress only on those points which have especially come within our own cognisance.

Chemical methods for ordinary analyses are fully given, while those methods which we only occasionally use have been merely sketched, or reference made to works where they are fully described. All the methods described in this book have been tested again and again by us and our pupils, and are as reliable as we describe them to be.

It is practically impossible to diagnose many of the functional diseases of the stomach from the symptoms alone, and the clinician who does not call chemical tests to his aid is bound to mass together under one or another heading, various functional disorders which ought to be kept entirely separate. Thanks to the introduction of the stomach-tube, one is now able to obtain the contents of the stomach, and find out what chemical changes, if any, are present, thus enabling one to draw conclusions as to the sub-division of the various functional diseases of the stomach.

In organic diseases of the stomach, chemical analysis is not nearly so important, since in these there are several signs and symptoms which point in one direction or the other.

It must be understood that the results obtained from the chemical analysis of the gastric contents can never alone be sufficient for the formation of a definite diagnosis of the various forms of gastric dyspepsia; each case has to be carefully considered in connection with the various symptoms and physical signs present, and the stomach analysis is merely to be regarded as an *aid* in making a more careful and detailed diagnosis.

The idea that any one chemical factor is pathognomonic of any special condition must also be at once put aside. The diagnosis of carcinoma of the stomach from the absence of free hydrochloric acid in the gastric secretions has now to be regarded as non-conclusive, unless the history and physical signs support the diagnosis. This is analogous to the fact that the presence of albumen in the urine is not pathognomonic of Bright's disease unless one has negatived its attribution to cardiac, digestive, or other causes, and has, in support of the Bright's disease theory, various other symptoms with possibly other chemical results, which point in that direction. The fact that albumen is not pathognomonic of Bright's disease does not, however, detract from the value of the urine analysis.

The chemical methods now employed in the diagnosis of stomach diseases have opened up a large field in the various functional disorders of the stomach. The more one studies the chemistry of the stomach the more one realises what a vast number of dyspeptics there are who suffer from functional disturbance of the stomach, the number of such patients being out of all proportion to the number of those who suffer from structural diseases of the stomach. It would appear that in everyday practice, where we have to deal with functional disease of the stomach more than with organic, it is practically essential to use chemical methods if we hope to arrive at a correct diagnosis. It is not sufficient, in cases of gastric dyspepsia, to say that the individual is suffering from acid dyspepsia; before one can hope to do any good by treatment of such a condition, one must isolate the particular form of acid dyspepsia present, whether it is due to increased hydrochloric acid, or to increased volatile acids. It must also be remembered that in cases of dyspepsia where the secretion of the gastric juice is found to be perfectly normal, the motor-power of the stomach may be found to be abnormal, leading to certain chemical changes in the gastric contents which account for the indigestion. In other cases again, where the chemistry and the motor-power of the stomach appear to be in no way out of order, the patient may, owing to alterations in the sensibility of the stomach, be suffering from various symptoms of indigestion, and the analysis of the gastric contents will, in such cases, enable one to make a diagnosis of gastric hyperæsthesia.

The investigation of intestinal diseases is complicated by the necessity of employing fixed diets of known composition, as the kind of diet taken has so great an influence on the normal appearance of the stools. If one examines the motions with merely a rough idea of the food which has been taken by the patient, one may be considerably misled in the conclusions arrived at, and further, it is imperative in the more complicated cases, to examine several motions on a fixed diet, since the composition—and more especially the quantity—of the normal fæces may vary from day to day, with the result that a true knowledge of the normal appearance of the stools can only be gained after a period of from three to five days.

For instance, in slight cases of catarrh of the bowels, only whitish mucus may be seen—possibly not in sufficient quantity to be considered pathological—while, if a series of motions are examined, mucus may be found, in some of the specimens, so loaded with epithelial cells and leucocytes as to lead to an undoubted diagnosis of catarrh of the bowels.

Or again, in ulcerative colitis, unless there is very extensive ulceration, one may not find blood in all the motions, and, perhaps, only occasionally, leucocytes or sloughs in sufficient quantity to enable one to be sure of making a correct diagnosis. Such being the case in organic diseases of the bowel, one naturally expects to have a yet more varied picture in functional disturbance, making the necessity of a long period of observation more important.

In describing the alterations in the fæces in various diseases of the bowel, we have given analyses of cases on different diets by way of illustration; we have included the urine analyses in order to give a rough idea of how the general metabolism is influenced. We have not discussed the results of the urine analysis, as it appeared to open up too large a field in general metabolism to be admissible in the present work, but the results given are of value in trying to gain a scientific insight into the general chemical changes which occur in the organism.

The results found in the chemical analyses of the fæces are discussed as showing the alterations produced in the different diseases of the bowel under consideration, and must only be taken as types to give a general idea of the conditions found. Our present knowledge of the alterations produced in the fæces in disease of the intestine does not allow of more definite conclusions, but when more facts have been accumulated in this connection, one may hope to be able to classify, not only the organic diseases of the bowels, but also the functional alterations which may occur in the intestines or secretions, just as is now possible in the case of the stomach.

PART I

DISEASES OF THE STOMACH

CHAPTER I

METHOD OF OBTAINING GASTRIC CONTENTS AND TEST MEALS

THE investigation of the alterations produced in the stomach by disease when one only had the vomited matter to examine was most unsatisfactory, and it was not until other methods of obtaining the gastric contents were introduced that the physician was able to gain accurate knowledge of the changes occurring in the stomach when that organ is deranged. Kussmaul[1] first made use of the stomach-tube as a means of obtaining the gastric contents for clinical diagnosis, and to this method is due all our present knowledge of the different forms of functional dyspepsia.

The idea that patients object to swallowing the tube has been found by all who employ it to be entirely fallacious. The majority of patients do not make the slightest objection, and even those few who do at first very soon become accustomed to it. In neurotic patients especially, where the stomach analysis is most valuable in making a diagnosis, one finds that the tube is easily swallowed in the majority of cases.

It is unnecessary in a book like the present to describe the stomach-tube in detail, as those who read these pages will be already familiar with the various tubes ordinarily employed, and it is only necessary to mention a few points which we have found useful. American tubes differ from the English ones in having the lower opening larger than the other eyelet. The size of the stomach-tube employed in practice is 19–23 of

[1] *Deut. Archiv. Klin. Med.*, vol. vi. p. 455.

the English scale, and it is advisable to use the largest size, as it diminishes the sensation of retching, owing to the œsophagus more easily contracting on the tube, and preventing any of the gastric contents coming up outside. Several operators have preferred having the stomach-tube and funnel made out of one piece of rubber, and in such a case, the complete apparatus will be 180 cm. long. The disadvantage of the continuous rubber tube is the impossibility of noting the stomach contents as they pass along. The most convenient form in practice is a piece of glass tubing about 8 cm. in length, inserted into the ordinary stomach-tube ; from this a suitable piece of tubing, about 70 cm. long, is connected with a large glass funnel. This form of apparatus is easily cleaned, and when not in use can be taken to pieces so that each part can be kept hanging straight. This is an important point, as all tubes should be kept straight, and not rolled. After use, the stomach-tube with rubber attachment should be washed by passing a large quantity of hot water through it, then some disinfectant, such as perchloride of mercury (1 in 1000), and finally, a stream of cold water, after which it should be hung up in some cool place until required for further use If it is merely desired to obtain the gastric contents for purposes of analysis, it is unnecessary to have a fresh tube for each patient if the foregoing precautions with regard to cleansing have been taken. In cases of long-continued lavage of the stomach, it is desirable for the patient to have his own tube, and, needless to say, special tubes must be kept for syphilitic and tubercular patients.

Insertion of the Tube.—When inserting the tube, it is very important that the operator should make no fuss, as the patient is apt to become nervous in such a case. If one takes the tube quietly, and dips it into warm water, and passes it down the patient's throat, the tube is in his stomach before he realises what is going on. Most of the difficulties one hears of in practice are caused by the doctor going through an elaborate process of oiling and greasing the tube, or other preparatory measures previous to its passage. In our experience, it has never been found necessary to use any form of lubrication except dipping the tube into warm water. In very rare cases it may be necessary to spray the patient's throat with a 5 per cent. solution of cocaine. The patient should be made to sit upright, and it is convenient to have tied round his neck an apron of waterproof material long enough to reach the slop-pail; by this means, the saliva will run down to the pail and prevent the soiling of the floor or the patient's clothes. The patient is directed to bend his head a little forward, and cautioned against throwing his chin up when attempting to swallow the tube. The natural tendency to throw the head back should be discouraged, as it narrows the opening of the œsophagus instead of widening it. The tube is then passed over the tongue to the back of the throat, and the patient told to swallow; while he is in the act of swallowing, slight pressure engages the tube in the œsophagus, and, by its muscular force, the tube is carried on into the stomach. In the event of any difficulty being experienced in getting the tube into the œsophagus, it is better to withdraw it at once and try again, as the patient is apt to become nervous if the tube does not go down quickly. The ordinary passage of the tube will occupy only a few seconds.

Obtaining the Stomach Contents.—If the stomach contents do not begin to flow when the tube reaches the stomach, it is advisable to move the tube slightly up and down so as to make sure that it has not doubled on itself, and that it has reached the level of the fluid. The patient is then directed to take some deep respirations, and if this is insufficient, to bear down with his abdominal muscles. If these methods are not efficacious, some operators have advised massage of the front of the abdomen, by which means, peristalsis appears to be set up and the stomach contents voided. Aspiration must at times be employed, and frequently it is sufficient merely to grasp the stomach-tube with the left hand, and with the right hand press out the air in the lower part of the rubber tubing; the fingers of the right hand are then tightly closed on the tube, and the left hand loosened. By repeating this manœuvre several times, a sufficient vacuum is obtained to raise the stomach contents to the level of the patient's mouth, when the syphon action begins. Boas[1] recommends a bulb tube for this purpose; the proximal end of the tube, after its introduction into the stomach, is pressed and the bulb squeezed, when the distal end is clamped and the bulb allowed to expand. By this method, a partial vacuum

[1] Boas, "Diagnostik und Therapie der Magenkrankheiten," 3rd Auf, p. 128.

is produced in the tubing, and the gastric contents will begin to flow.

The simple apparatus of Rosenau[1] has many advantages over other more complicated apparatus. It consists of a graduated bottle with a capacity of 200–300 cm., which can be connected to an ordinary stomach-tube and closed by an india-rubber stopper. The stopper has three valved apertures, any of which can be opened by a rotary movement, and communicate with an elastic bag, so that the atmospheric pressure within the bottle can be exhausted or increased at will.

The objections to using methods of aspiration in obtaining the stomach contents are that it complicates the apparatus, making the patient imagine that the operation is more important than it really is, and the danger of causing too great a vacuum and so sucking some of the mucous membrane of the stomach into the eyelets, and detaching it from the stomach wall, thereby leaving a raw surface. With the apparatus described above, the suction can be regulated, so that the latter danger is avoided. It must always be borne in mind that if one is to obtain gastric contents in a suitable condition for analysis, no water whatever must be added. It is perfectly impossible to obtain correct results where this has been done; however carefully the quantity of water put into the stomach is measured, one can never be sure what allowance to make for the quantity of water added, as it is extremely difficult to empty the stomach completely.

It has frequently been stated that the use of the stomach-tube is attended with danger, but in our opinion it can, under certain conditions, be used with impunity in practically all cases. One must naturally use common sense, and not employ it in advanced valvular disease when compensation has failed if there is the slightest straining on the part of the patient. It is probably better not to use the stomach-tube in cases of arterio-sclerosis with high tension; in aortic aneurism, one certainly ought to beware of using it, as also in some lung conditions, severe bronchitis, and pulmonary tuberculosis in the advanced stages. In cases of gastric ulcer where there has been recent hæmorrhage, the tube should not be used; but, in doubtful cases, no harm will probably arise from its use. When one considers how soft the rubber tube is, one would hardly expect

[1] *Brit. Med. Journ.*, April 23, 1904, p. 958.

it to cause much damage to the mucous membrane. In short, it may be said that, under ordinary conditions, there is not the least danger incurred in passing the tube.

Capacity of the Stomach.—After having obtained the stomach contents by means of the stomach-tube, the estimation of the capacity of the stomach can be conveniently carried out by one or other of the following methods :

(1) Before removing the tube, one can fill the stomach with a measured quantity of water from the funnel until the patient complains of feeling distended. The drawback to this procedure is that the water presses the larger curvature of the stomach downwards, and tends to enlarge the capacity of that organ, while there is no certainty that the water has reached the cardiac end of the stomach when the patient complains of distension. In fact, the feeling of discomfort and pressure may cause attempts at vomiting when the stomach is not completely filled, and individual idiosyncrasies may lead to feelings of discomfort before the stomach is really distended with water.

(2) To obviate the disadvantage and discomfort of the water method of estimating the capacity of the stomach, it has been proposed to introduce air by means of the Boas bulb, or by attaching a Higginson's syringe in order to distend the stomach and determine the position and capacity by means of percussion. In this case also, the condition of the stomach wall prevents an accurate application of the method. In cases of atony, the stomach wall very easily becomes over-distended, although only slight pressure has been produced as measured by means of the manometer.

(3) Various chemical methods have been employed for distending the stomach, such as giving the two portions of a seidlitz powder dissolved in water one after the other, or a small quantity of citric acid in water is administered to the patient, and immediately afterwards a solution of sodium carbonate. The liberated carbonic acid distends the stomach, and, by means of percussion, one is able to estimate its capacity.

Ost[1] has collected the results of various observers with reference to the capacity of the stomach, and he gives a table as follows :

1 " Beiträge zur Bestimmung der Capacität des Magens," quoted from Boas' " Magenkrankheiten," i. p. 10.

Ewald	250–1680 cm.
Luschka	1500–2000 ,,
Schüren	2430 ,,
Beneke	3000 ,,
Brinton	3130 ,,
Soemmering	2500–5500 ,,
Henle	2500–5500 ,,

Kussmaul found the capacity of the stomach to be 2600 cm. It must be remembered that a correct estimation of the capacity of the stomach depends, to a great extent, on the condition of the patient, whether he is nervous or the reverse, whether he is familiar with the stomach-tube, or, in the case of chemical means being used, accustomed to the sensation of being distended. All these points have to be taken into consideration before one is in a position to express an opinion as to the stomach being pathologically enlarged or not. As a general rule, one may say that if the stomach will contain more than 3000 cm. of water, it is probably dilated. The condition in which it is most important to obtain an idea of the size of the stomach is when it is uncertain whether the resonance found on percussion in the region of the umbilicus is due to a dilated stomach, or to an enlarged transverse colon. Any of the methods mentioned can be used to determine the approximate size of the stomach, while by means of a long rectal tube, the transverse colon can be filled with air, and the percussion note will decide whether the clear note varies during the latter procedure or not, and one can tell whether one has to deal with a tympanitic note due to dilated colon or to a dilated stomach.

TEST MEALS

It must be remembered that different food materials, as shown by Pawlow, excite the secretion of gastric juices in different proportions, and it is, therefore, very important, if one wishes to compare one analysis with another, to note exactly what diet the patient has taken, and the period of time since he took it; otherwise, the chemical analysis is worthless. The experiments of Pawlow[1] show that different kinds of food have a corresponding definite hourly rate of secretion, and call forth characteristic alterations in the proportion of the juice. On

1 Pawlow, "The Work of the Digestive Glands," translated by W. H. Thompson, p. 35.

a meat diet, the maximum rate of secretion occurs during the first and second hours, and in both, the quantity of gastric juice is approximately the same. Bread gives a maximum secretion of gastric juice during the first hour, while in the case of milk it occurs during the second and third hours. On the other hand, the most active formation of juice occurs with meat during the first hour, with bread during the second and third hours, and with milk during the last hour of secretion. We thus see that the maximum out-flow, as well as the whole curve of secretion, is characteristic for each diet.

These valuable results of Pawlow show how important it is, in comparing one case with another, to have a fixed diet for patients. It is practically immaterial what diet one uses, but for the sake of convenience, we have preferred to use a test breakfast.

In giving a test meal, it is important to see that the stomach is empty, otherwise, the analysis may be vitiated; if the remains of food from the previous day are still present in the stomach, one cannot obtain a proper quantitative analysis representing the juice excreted for the new meal.

The various test meals employed in practice for the diagnosis of stomach diseases can now be described.

(1) **Test Breakfast.**—Ewald[1] long ago recommended, as a test breakfast, that the patient should take one roll of white bread about 35 grams and 400 c.c. of water or weak tea without milk or sugar, and, that one hour afterwards, the contents of the stomach should be syphoned off for examination.

In practice we find it more convenient to give two cups of weak tea with a little milk, and two slices of dry toast. The advantage of either of these meals is that one is able to obtain the stomach contents one hour afterwards; the semi-fluid contents easily flow up the tube without any blocking which is apt to occur when the larger ingesta, more especially meat, are given. The meal can be also taken by patients with weak digestions or intolerant stomachs. The disadvantage is that the meal has a very slightly stimulating effect on the gastric secretion, but this is negatived when one remembers that the object of its use is to obtain comparative results.

[1] Ewald, "Klin. der Verdauungskrankheiten," ii. 1893, p. 285.

(2) **Boas's Test Meal.**[1]—This consists of a teaspoonful of rolled oats and 1000 c.c. of water boiled down to 500 c.c. and given with the addition of milk, but without any salt. The stomach contents are removed for examination one hour later. The meal was introduced by Boas with the special object of estimating the quantity of lactic acid present in the stomach with particular reference to carcinoma. The bread or toast given in the ordinary test breakfast always contains some lactic acid, and such meals are, therefore, not suitable when the quantity of lactic acid present in the stomach has to be estimated.

The following precautions must be observed before the Boas test meal is given if one is to obtain a satisfactory analysis. The previous night, the stomach must be washed out with water until the fluid returns absolutely clear, and this process should be repeated just before giving the test meal. Otherwise, there is a great chance of some of the lactic acid from the previous meal being retained in the stomach, thus vitiating the results.

(3) **Riegel's Test Meal.**[2]—The patient takes, while fasting, a soup-plateful of bouillon or broth, 150 to 200 grams of beef steak, and 50 grams of *purée* of potatoes. In order to prevent the lumen of the tube becoming obstructed, it is advisable to have the meat finely minced.

Leube[3] has recommended a similar meal, passing the stomach-tube after seven hours. If one finds the stomach then empty, one can consider that the motor-power is not delayed, but one obtains no evidence as to whether the gastric secretion is normal. In many pathological conditions, when the ingesta are passed on into the duodenum in the normal, or even a shorter space of time, chemical analysis proves that the gastric contents have either a deficiency or excess of hydrochloric acid. It would appear that the time for passing the tube after this meal varies in different individuals. In some cases, it can be passed after two or three hours, while in others, one has to wait for five or six hours before the results are obtained. Riegel states that he finds four hours after the ingestion of the meal the best time for carrying out the first diagnostic examination. If the stomach

1 *Zeitschr. f. Klin. Med.*, vol. xxv.
2 Riegel's "Magenkrankheiten," p. 82.
3 *Deutsch. f. Klin. Med.*, vol. v. p. 33.

is found to be empty by that time, one has learnt that the motor-power is normal, if not accelerated, but no information whatever is obtained as to the hydrochloric acid or peptic digestive power. In those cases where the stomach empties itself in four hours, it is necessary to repeat the meal and pass the tube at an earlier time, preferably two hours after the meal. On the other hand, if at the end of four hours, there is still a large amount of digestive material in the stomach, one repeats the operation at a later period. In no case ought one to be content with only one investigation for the drawing of conclusions.

The disadvantage of this test meal is that, if one wishes to make a chemical examination, one has very mixed gastric contents to deal with, and the comparative results, in our own experience, have not been very satisfactory. On the other hand, for microscopical examination, this method is very valuable in showing starch granules or muscular fibres in a more or less digested condition. Undoubtedly, the principal value of the meal is in showing the motor-power of the stomach, and not the estimation of the gastric digestive power.

(4) **Salzer's Test Meal.**[1]—Salzer's test meal consists of giving two meals, one after the other. The first consists of 30 grams of finely minced cold roast beef, 250 c.c. of milk, and 50 grams of rice with one soft-boiled egg. Four hours later, a second meal of tea and roll as in Ewald's test breakfast, is given, the contents of the stomach being syphoned off one hour after the second meal. In this method, Riegel's test meal is combined with the test breakfast. As has been already shown, the stomach which possesses normal motility would be empty in about five hours after Riegel's meal, so that, if the motor-power is normal or slightly in excess, there ought to be no remains of the first meal in the stomach contents, but merely the residue of the test breakfast for analytical purposes.

The disadvantage of this method is that complication in the gastric stimulation is caused by the administration of two meals so closely following each other, as we have shown to be pointed out by Pawlow in his experiments. It is also found that the comparison of the analyses obtained in different cases does not give very constant results. We therefore prefer to use Riegel's test dinner for investigating the motor-power of the stomach,

[1] Boston, "Clinical Diagnosis," p. 316.

and not to complicate it with the analysis after the test breakfast, leaving the latter till another occasion.

(5) **Klemperer's Test Meal.** — The patient takes while fasting, 500 c.c. of milk, and two rolls of white bread, the stomach contents being removed two hours later. It is essential, if one wishes to obtain maximum results on a milk diet, to remove the gastric contents at a longer interval than one hour, since the secretion has not reached its maximum by that time; Pawlow having found in his careful investigations that milk does not give its maximum stimulation to the gastric contents for two or three hours. In this diet, therefore, one has no advantages over the ordinary test breakfast, and in making comparisons, one must remember that the quantity of hydrochloric acid will be higher than that obtained when the simple test breakfast is given.

(6) **German See Test Meal.**[1]—The patient takes, while fasting, 100 to 150 grams of bread, 60 to 80 grams of finely minced meat and one glass of water, the stomach contents being removed two hours later.

When employing this diet, one obtains gastric contents which are stimulated by proteid (meat, the gastric secretion of which would be at its highest in two hours), and by carbohydrates (bread, which would give its maximum stimulation in the first hour). And the diet appears to us to have no advantages over the others described.

1 *Acad. de Med.*, Paris 1888, 3rd series xix. p. 72.

CHAPTER II

MACROSCOPIC AND MICROSCOPIC EXAMINATION OF GASTRIC CONTENTS

The gastric contents having been obtained after any of the test meals described, should be inspected, and the appearance, colour, and odour noted. For this purpose, it is advisable to place the contents in a conical vessel, noting the various layers which form, and isolating, by means of a pipette, specimens from these layers for separate examination.

The test breakfast yields gastric contents which form three distinct layers in the vessel, the lowest, consisting of a dense mass of finely divided starch residue, above this, a deeper layer of turbid fluid, while the uppermost layer consists of clear liquid with some froth on the surface, and showing bubbles of gas slowly rising on the top. Increased gas fermentation will be found to occur in all cases of motor insufficiency, leading to stagnation of the gastric contents. In cases of motor insufficiency, it is not at all uncommon to find the lowest layer contain distinct lumps of toast, in spite of mastication having been well carried out. One of the functions of the motor-power of the stomach is its churning action, allowing the gastric juice to act more easily on the ingesta and thus break them up, so that any diminution in the movements of the stomach will be shown by the insufficient breaking-down of the toast.

Reigel's test dinner gives gastric contents, in which—if they are removed before the stomach is empty—one finds in the lowest layer a dense precipitate of partially digested pieces of meat. In those cases where there is excessive digestive activity, the lower layer may be almost converted into fluid, and only some remnants of muscular fibres and a few starch granules are to be seen by the naked eye examination. A rough idea of the digestive power of the stomach can be obtained by inspection. The gastric contents in some cases give no reaction for free hydrochloric acid, and in spite of its absence, one finds only finely broken-up residue ; while, in other cases, one finds a large quantity of coarsely divided food. The quantity and the breaking-down of the two classes of gastric contents show very great differences, for in the first case, the peptic digestion is far better than in the second. In the first, the stomach very nearly approaches the normal, the proteids having been digested, although the gastric secretion has not gone quite far enough to form free hydrochloric acid. In the second case, the production of free hydrochloric acid has been much below the normal, as shown by the large quantity of undigested or partially digested pieces of meat, and if this gastric contents had been examined chemically, one would have found a very marked diminution in the quantity of hydrochloric acid.

The conical vessel allows one to see if there is any blood, mucus, bile, or pus present in the gastric contents, specimens of which can be obtained for further examination by means of a pipette.

It is very important in all cases of stomach disease to take special note of the odour of the gastric contents obtained after the employment of one or other of the test meals. In normal gastric contents after a test breakfast, there ought to be no objectionable smell present, whilst in pathological conditions, it may vary from a slightly sour to a more or less putrid stinking odour. The irritating smell of butyric acid is most characteristic, and, as mentioned later, practically does away with the necessity of chemical examination for this substance. In cases of atony of the stomach, where there is long-continued stagnation of the gastric contents, one may obtain a definite smell of sulphuretted hydrogen, and occasionally, a sufficient quantity of this substance is present to blacken moist lead paper. In malignant disease, it is not uncommon to have a distinctly putrid smell in cases where the gastric carcinoma has ulcerated. In cases of intestinal obstruction, or where an abnormal connection between the stomach and intestine has arisen, one may obtain a fæcal odour.

MICROSCOPIC EXAMINATION OF THE GASTRIC CONTENTS

The microscopic examination of the contents removed from the stomach after any of the various test meals is not so important as the macroscopic, and far less so than the chemical examination. It has already been pointed out that, if the gastric contents are put in a conical vessel, one can, by means of a pipette, separate any portions desired for microscopic examination.

One finds in some cases after Riegel's test meal that the muscular fibres still retain their cross striation, and have been little acted on by the gastric juice. The chemical analysis will prove the absence or diminution of hydrochloric acid, and probably, a decrease of pepsin. In other cases, one finds microscopically that the muscular fibres have been well digested, but that the starch digestion has not proceeded at an equal rate. In these cases, one generally finds that one has to deal with hyperhydrochloria. The deficiency of starch digestion is very easily demonstrated by means of the microscope if one uses a solution of potassium iodide and iodine, which stains the starch a blue colour.

Quantities of fat are sometimes recognised in the stomach contents by aid of the microscope, but they have little pathological significance.

Epithelial cells will be found in the sediment, but they are not of much diagnostic value, although in rare cases cancer cell nests may be found in the particles of the sediment of gastric contents. We, however, agree with Riegel that these are of very rare occurrence.

In washing out the stomach with water after having removed the gastric contents by syphoning, or in washing out a fasting stomach, it is not uncommon to find in the wash-water small pieces of gastric mucosa. Einhorn[1] has made a special study of these, and gives in his book numerous plates showing the various forms found in this way; the conclusions to be drawn from the examination of such specimens are, however, unreliable, as Einhorn himself has stated.

In some cases the microscope may reveal the presence of blood corpuscles; very small quantities can be distinguished by this

[1] Einhorn, "Diseases of the Stomach," p. 78.

means where no positive chemical reaction can be obtained. And it must not be forgotten that blood in such small quantity may come from the pharynx, owing to slight bruising or straining with the tube, and may have little significance.

It is unnecessary here to describe the various micro-organisms which may be recognised by the aid of the microscope. Oppler and Boas[1] have drawn special attention to a form of bacillus which they consider to be present in the gastric secretion in cases of carcinoma. This bacillus is easily recognised by its large size and immobility, and Kaufmann has shown that it possesses the power of converting various sugars into lactic acid. The question of the presence of lactic acid in malignant disease will be discussed later on, but it is important to remember that in most cases of carcinoma one finds this lactic acid bacillus.

The view that the stomach is not essential for the digestion of proteids, and that the hydrochloric acid present in the gastric secretion really acts as an inhibitor of the various micro-organisms which have been swallowed by the mouth, is strongly held by Bunge[2] and others. It has, however, been definitely proved that the addition of hydrochloric acid to the gastric contents does not entirely destroy micro-organisms, and there are numerous cases in which, in spite of an excess of hydrochloric acid, micro-organisms are present. At the same time, it will be found in these cases that the condition is accompanied by diminished motility of the stomach. In all probability, the hydrochloric acid does inhibit, to a certain extent, the micro-organisms present in the stomach, provided that it is performing its functions healthily. The cholera bacillus, certain streptococci, &c., are killed by the gastric juice, while others, especially spores, are not acted upon. Also gastric juice diminishes the action of certain toxalbumins, such as tetanotoxin and diphtheria toxin, as has been shown by Nencki, Sieber, and Schounow.[3] Under pathological conditions, the hydrochloric acid—owing to its weak action—is insufficient to be of material service.

Numerous varieties of sarcinæ have been described, but the cultivation of the different varieties is of more scientific than practical interest. The presence of sarcinæ in the stomach

[1] *Deut. Med. Wochenschr.*, 1895, No. 5.
[2] *Lehrbuch der physiol. Chemie*, 1887.
[3] *Centralb. f. Bacteriol*, vol. xxiii.

indicates the retention of stomach contents, whether the retention is due to atony of the stomach, gastritis, or even structural obstruction, while, in malignant disease, as shown later, they are absent.

Crystals of cholesterin, leucin, oxalate of lime or ammonium magnesium phosphate may be recognised microscopically, but they have no clinical significance.

CHAPTER III

CHEMICAL EXAMINATION OF GASTRIC CONTENTS—TOTAL ACIDITY, VOLATILE ACIDITY

THE quantitative estimation of the amount of acidity in a given quantity of gastric contents is among the most useful analytical data we have in making a diagnosis in gastric diseases.

Total Acidity.—Ewald[1] describes a method for estimating the acidity due to hydrochloric acid, organic acids and acid phosphates, which is generally known as " total acidity."

Method :—Ten c.c. of filtered gastric contents are measured into a small beaker, and 20 to 30 c.c. of distilled water added, and, as an indicator, three drops of 1 per cent. alcoholic solution of phenolphthalein. The solution is kept constantly stirred, during which time a decinormal solution of sodium hydrate is allowed to run, drop by drop, into the beaker until the red colour which at first appears does not deepen on the addition of a further drop. The number of c.c. of sodium hydrate used is then read off, and this multiplied by ten will give the quantity of decinormal sodium hydrate required to neutralise 100 c.c. of gastric contents. This number is that which is generally known as " total acidity " in modern books on diseases of the stomach. It must, however, be remembered, as we have stated above, that this is really the amount of total acids in 100 c.c. of gastric contents, and should never be taken to represent the amount of hydrochloric acid actually present, being in reality only the total acidity due to hydrochloric acid, the various organic acids and acid phosphates present in the stomach. In describing the method of estimating the quantity of volatile acids, we will show how the total amount of volatile

[1] *Klinik der Verdauungskrankheiten*, vol. ii. 1893, p. 34. Proceeding first recommended by Geigel and Blass, " Procentuale und absolute Acidität des Magensaftes," *Zeitschr. f. Klin. Med.*, vol. xx. No. 3, and also by Geigel and Abend, " Die Salzsäure Secretion bei Dyspepsie Nervosa." Virchow's *Archiv.* vol. cxxx. No. 1.

acids can be estimated, and, by subtracting the acidity due to volatile acids from the total acidity found by the above method, we have the acidity which is represented by the quantity of hydrochloric acid and acid phosphates; and, since the acid phosphates are, as a rule, only small in amount, this quantity may be taken as roughly representing the total acidity due to hydrochloric acid.

The normal acidity in the gastric contents as estimated by the above method, is found, after taking a test breakfast, to vary between 40 and 60.

The lowest total acidity that we have met with amongst a large number of stomach analyses, was 14, when 13·6 of the acidity was found to be due to volatile acids. This was in a case of malignant disease at the cardiac end of the stomach.

As a general rule, the total acidity is found not to be less than from 18 to 20 in cases of hypohydrochloria, with volatile acids varying from 2 to 3·5.

In cases of hyperhydrochloria, which are very much more frequent than cases of hypohydrochloria, the acidity as a rule varies from 80 to 100, although it is not at all uncommon to get a total acidity as high as 120 or even higher.

Volatile Acidity.—Gastric contents have always been found to contain, after any test meal, volatile acids in greater or smaller quantities.

Butyric acid, acetic acid, and fatty acids are probably the chief volatile acids present in the stomach contents, and they are especially increased if there is any stagnation; and as will be shown later, they may be present in increased quantities when free hydrochloric acid exists in normal quantity, or even in excess.

The recognition of these acids is generally a simple matter, owing to the intensely acid smell which one notices when obtaining the gastric contents by means of the stomach-tube.

If some of the gastric contents are placed in a test-tube and a strip of blue litmus paper (previously moistened), stretched over the top, one finds, on gently heating the tube, reddening of the paper, owing to the liberation of the volatile acids.

For the estimation of the volatile acids, Hermann Strauss[1] introduced a method by which fresh unfiltered gastric contents

[1] *Deut. Med. Wochenschr.*, 1896, No. 38.

were poured into large sterilised fermentation tubes. The fermentation tubes were then placed in an incubator at 37° C. for twenty-four hours. The proportionate amount present is estimated as follows :

One or more bubbles of gas	Very slight fermentation.
Tube filled to one fifth with gas	Slight fermentation.
Tube filled between one fifth and one half	Moderate fermentation.
Tube filled between one half and three-quarters	Much fermentation.

It is obvious that this method cannot be very accurate, as the gastric contents are under totally different conditions from the normal, being removed from the modifying influence of gastric secretions, saliva, and mucus.

Other methods have been introduced, none of which appear to be very satisfactory. Some ten years ago, a method which has been found to yield very satisfactory results, was introduced in the Department of Pathological Chemistry, University College, London. The method has the merit of being feasible for clinical work.

Harley's Method of estimating the Total Volatile Acids in the Gastric Contents.—A certain quantity (preferably about 25 c.c.) of unfiltered gastric contents is poured into a distillation flask, and 100 or more c.c. of water added. A current of superheated steam is driven through the flask, and a small flame placed underneath it. The superheated steam, raising the contents to boiling-point, drives off the volatile acids which distil over through a condenser into an Erlenmeyer containing about 10 c.c. of decinormal solution of sodium hydrate. After about thirty minutes, the Erlenmeyer is removed and a few drops of neutral solution of litmus added to the sodium hydrate solution. The fluid is then titrated by rapidly running into it a decinormal solution of sulphuric acid until a neutral reaction is obtained. The quantity of decinormal solution of sodium hydrate neutralised by the volatile acids is then easily obtained. Multiplying the number by four, if 25 c.c. of gastric contents were taken, will give the quantity of volatile acids in 100 c.c. of gastric contents.

This method is somewhat similar to that originally employed by von Mering, in which the gastric contents with water are distilled, and when boiled down to about one-third of their volume, a fresh quantity of water is added, and again boiled to about one-third; this process is repeated some four or five times, the liberated volatile acids being collected by means of a condenser in a decinormal solution of sodium hydrate and titrated as above. The von Mering method has possibly the same accuracy as the one which we have described, but it is more difficult to carry out, and needs more looking after.

Both these methods have one possible cause of error,—some of the organic matter, as proteids or fat, may be broken up by the superheated steam, and lead to too high a quantity of volatile acids. At the same time, even if this should be the case, the quantity broken up when control analyses are done is equal, for we have found the control analyses to be sufficiently accurate for all diagnostic purposes.

As an example of the accuracy of this method for the quantitative estimation of the volatile acids expressed in c.c. of one-tenth Normal NaOH,[1] the following results may be given:

1	3·6	2·8 control.
2	3·2	2·8 „
3	7·0	7·5 „
4	7·0	7·0 „

In the above we have illustrated two analyses with a small quantity of volatile acids, and two analyses with a large quantity of volatile acids, and it appears that the results are very close, and are certainly sufficiently accurate, as before stated, for all diagnostic purposes.

The normal amount of volatile acids, as estimated by Harley's method, varies from 2 to 5, although we have found as much as 11 in an individual apparently suffering from no gastric disturbance. In all cases where we have found a larger quantity than this, there have been definite symptoms of dyspepsia, and as a rule, in those cases where the quantity is above 5, the patient is suffering from symptoms of acid dyspepsia.

In one case we found 16 with a total acidity of 62, and in another, 25 with a total acidity of 60. Both these patients had neurotic histories, and showed signs of delayed motility with some dilatation of the stomach.

In a case of chronic tubercular disease of the lungs (healed),

[1] Harley and Leney, *B.M.J.*, Oct. 27, 1899, p. 1271.

where there was marked increase of mucus in the gastric contents, and evidently chronic gastric catarrh, we found volatile acids varying from 18 to 30, with a total acidity varying from 40 to 70 in some ten analyses after test breakfasts.

In a case of malignant disease of the cardiac end of the stomach, we found 22·4 volatile acids with a total acidity of 47.

In hypohydrochloria, we found volatile acids 14 with a total acidity of 30.

It will thus be seen that the quantitative estimation of volatile acids is of considerable importance in determining how much of the total acidity is due to volatile acids.

In hyperhydrochloria it will be found that, even where the total acidity is considerably increased, one may get an increase in the quantity of volatile acids. As a general rule, however, in marked cases of hyperhydrochloria, the volatile acids are only slightly, if at all, increased.

In some cases where the total acidity is higher than normal—say, 70 to 90—it may be found to be due, not to the increase of hydrochloric acid, but to marked increase in the quantity of volatile acids, so that increased total acidity is really only an apparent increase in consequence of the great increase in the volatile acids.

CHAPTER IV

CHEMICAL EXAMINATION OF GASTRIC CONTENTS (*continued*)—QUALITATIVE AND QUANTITATIVE METHODS FOR THE RECOGNITION OF FREE HYDROCHLORIC ACID

(1) **Methyl-Violet.**[1]—A very diluted watery solution of methyl-violet is placed in two test-tubes, each about one-third full. To one of these, one c.c. of filtered gastric contents, and to the other, an equal quantity of distilled water, is added. The two test-tubes being held up to the light, one notices the appearance of a violet colour if free hydrochloric acid is present, the colour gradually changing to blue on standing.

The methyl-violet test can also be employed by allowing a drop of filtered gastric contents to come in contact with a drop of methyl-violet solution in a porcelain capsule, thus obtaining a violet colour changing to blue on standing, at the junction of the two fluids.

This test is mainly of historical interest, V. d. Velden having employed it for detecting the presence of free hydrochloric acid in his classical work on " Carcinoma of the Stomach." The test is not a delicate one.

(2) **Congo Red.**—A watery solution of congo-red or filter-paper previously soaked in congo-red solution, is dried and kept in stock, cut up into strips.

A drop of gastric contents placed on congo-red paper gives an intense blue colour if free hydrochloric acid is present.

A drop of gastric contents and one drop of congo-red solution are allowed to come in contact with each other in a porcelain capsule, when, in the presence of free hydrochloric acid, a blue colour will appear at the junction of the two fluids.

The congo-red solution is a very sensitive reaction for free hydrochloric acid.

(3) **Tropäolin OO.**—A solution of tropäolin, or filter-paper

[1] V. d. Velden, *Deut. Arch. f. Klin. Med.* 1879. Bd. xxiii. 49.

previously soaked with tropäolin, is used in the same manner as the congo-red solution; in the presence of free hydrochloric acid, one obtains a lilac or blue colour.

This method is not so sensitive as congo-red, and only acts with free hydrochloric acid, the organic compounds of hydrochloric acid not giving the reaction.

(4) **Günzburg's Solution.**[1]—The solution employed by Günzburg consists of:

Phloroglucin . . .	2 grams.
Vanillin	1 gram.
Absolute Alcohol. . .	30 grams.

This solution must be kept in a dark glass bottle, as light easily decomposes it.

A few drops of Günzburg's solution are added to a few drops of filtered gastric contents in a porcelain capsule, and gently heated over a small flame. If free hydrochloric acid is present, a bright red colour appears at the margin, gradually extending over the whole surface. It is advisable to hold the capsule in the fingers in order to avoid over-heating, and consequent charring, as, should this be the case, a yellow colour appears, and no conclusions can be drawn. This is a very pretty test and used to be considered the most delicate for clinical purposes: it is useful for demonstration purposes.

(5) **Dimethyl-amido-azo-benzol.**—The method for detecting the presence of free hydrochloric acid by the use of 0.5 per cent. of alcoholic solution of dimethyl-amido-azo-benzol was first introduced by Töpfer.[2]

One or two drops of dimethyl-amido-azo-benzol solution, when added to gastric contents, will yield a beautiful crimson colour in the presence of free hydrochloric acid, while if free hydrochloric acid is not present, one merely observes a dirty yellow colour.

This method of Töpfer is undoubtedly the most valuable we have at the present moment for demonstrating the presence of free hydrochloric acid. Its advantages are:

(*a*) A solution of dimethyl-amido-azo-benzol keeps for a considerable time.

(*b*) It is by far the most easily applied test for recognising

1 *Centralblatt. f. Klin. Med.*, 1887, No. 40.
2 *Zeitschr. f. Physiol. Chemie*, Bd. xix. Heft 1.

the presence of free hydrochloric acid of all those in common use. It is the most certain in reaction, as neither excess of lactic acid nor the presence of acid phosphates will cause the colour to appear, and t alone is all that is necessary for clinical purposes in definitely clinching the presence or absence of free hydrochloric acid.

(*c*) It is not necessary to filter or prepare the gastric contents in any way.

QUANTITATIVE ESTIMATION OF HYDROCHLORIC ACID

As hydrochloric acid is the most important acid secretion of the stomach, it has been thought that the knowledge of the quantity present in pathological conditions is of great importance in the proper diagnosis of diseases of the stomach, and a great number of investigators have carried out researches in the subject. Numerous methods for the quantitative analysis of free hydrochloric acid have been introduced, and each has its own supporters. We have repeatedly tried most of these methods, and have found one or other more or less useful. But after some years teaching, and after the experience gained in seeing the manner in which the methods have been employed by advanced students, we have slowly come to employ only two methods, which appear to us to be the most accurate and most easily carried out.

(1) **Leo's Method.**[1]—This method depends upon the fact that all the acids, including the proteid combined hydrochloric acid, present in the gastric contents, are neutralised by calcium carbonate, while the acidity due to the acid phosphates and other alkaline substances is not altered, so that one titrates one portion of the fluid direct, and the other after treating it with calcium carbonate.

To ten c.c. of gastric contents, five c.c. of chloride of calcium solution are added, a few drops of phenophthalein being used as an indicator; one titrates with one-tenth normal solution of sodium hydrate. A further fifteen c.c. of gastric contents are treated with one gram of dry powdered calcium carbonate and filtered through ash free filter-paper. Ten c.c. of the filtrate

[1] Hoppe-Seyler's *Chemischer Analyse*, 1903, p. 519.

are then taken, and after passing a stream of air through to remove any excess of carbonic acid, five c.c. of concentrated calcium chloride solution are added, using phenophthalein as an indicator, and again titrated with one-tenth normal solution of sodium hydrate.

The difference between the two results obtained gives the total acidity, provided that the stomach contents do not contain lactic acid or volatile fatty acids. In these cases, it is necessary, previous to carrying out the analysis, to extract the lactic acid and volatile fatty acids with ether.

(2) **The Prout-Wynter Method.**—The unfiltered gastric contents are measured off, and one must see that the quantity is sufficient to allow of its being divided into three equal parts for this analysis; it is advisable to employ not less than fifteen c.c., and in practice we prefer thirty c.c.

(*a*) Ten c.c. of unfiltered gastric contents are placed in a platinum capsule, and ten to twenty drops of saturated solution of sodium carbonate added. The capsule is then placed on a sand-bath, and gradually evaporated to dryness, care being taken that none of the contents are lost through "spitting." When thoroughly dry, the contents are incinerated, and after all the organic matter has been burnt off, the capsule is heated to redness. The contents are then washed into a beaker by means of a small quantity of distilled water, and labelled, No. 1.

(*b*) A further ten c.c. of unfiltered gastric contents are measured into a second platinum capsule, and dried down on a sand-bath until all the fluid has disappeared; just before charring begins, ten to twenty drops of sodium carbonate solution are added, run over the whole surface, and the fluid again evaporated to dryness. The contents are then incinerated, raised to red heat, and washed with distilled water into a beaker labelled, No. 2.

(*c*) A third ten c.c. of gastric contents are placed in a platinum capsule, carefully dried down on the sand-bath, incinerated and raised to red heat, the residue being washed with distilled water into a beaker labelled, No. 3.

To each beaker a few drops of nitric acid are added, until effervescence ceases, and fifteen c.c. of decinormal solution of silver nitrate.

The contents are filtered into beakers correspondingly numbered, and the residue washed three or four times with distilled water.

To the filtrate a few drops of iron alum solution are added as an indicator. It is then titrated by rapidly running in a solution of decinormal potassium sulphocyanide, quickly stirring until a salmon-pink appears, and remains for a minute.

Each c.c. of decinormal silver nitrate equals a c.c. of decinormal sulphocyanide of potassium, and each c.c. represents 0·00365 grams of hydrochloric acid.

The number of c.c. of decinormal sulphocyanide of potassium used in each case is read off, subtracted from the quantity of decinormal solution of silver nitrate originally taken, and the remainder multiplied by 0·00365, by which means one obtains the quantity of hydrochloric acid contained in each ten c.c. of gastric contents.

The rationale of the method is as follows:

To the first capsule one adds sodium carbonate in order to convert all the hydrochloric acid present into sodium chloride, none of which chlorine will be driven off by heating, and the number of c.c. of potassium sulphocyanide required gives the total amount of hydrochloric acid present.

The contents of the second capsule are dried before the sodium carbonate is added; therefore, all the hydrochloric acid present as free hydrochloric acid is driven off, while the addition of the sodium carbonate prevents the hydrochloric acid combined with the proteids from being driven off.

The third capsule only gives the amount of hydrochloric acid present in the form of mineral salts, as in drying down, the free hydrochloric acid is lost, and in incinerating, the hydrochloric acid combined with the proteids is driven off, so that only the chlorine combined with the mineral salts is left. Therefore,

No. 1 Capsule	=	total hydrochloric acid.
No. 1 minus No. 2	=	free hydrochloric acid.
No. 2 minus No. 3	=	proteid hydrochloric acid.
No. 3	=	mineral hydrochloric acid.

This method is very accurate, as shown by comparison of the results obtained with control analyses. The following table of four analyses may be taken as an average specimen of the results one may expect to find in normal gastric contents:

TABLE I.—SHOWING THE ACCURACY OF THE PROUT-WYNTER METHOD

Total HCl.	Free HCl.	Proteid HCl.	Mineral HCl.
(1) 0·32 0·31 (Control)	0·020 0·010 (Control)	0·23 0·23 (Control)	0·070 0·070 (Control)
(2) 0·32 0·32 ,,	0·020 0·020 ,,	0·25 0·24 ,,	0·050 0·050 ,,
(3) 0·30 0·28 ,,	0·006 0·006 ,,	0·27 0·25 ,,	0·025 0·025 ,,
(4) 0·32 0·31 ,,	0·004 0·007 ,,	0·27 0·27 ,,	0·050 0·040 ,,

If many stomach analyses have to be done, it is as well to have at least three capsules. It is possible to use the same capsule for the three separate analyses, but much time is thereby lost, and the method becomes very tedious.

(3) **Töpfer's Method.**[1]—In this method, filtered gastric contents have to be employed, and one must have sufficient to divide into three quantities.

(*a*) Ten c.c. of filtered gastric contents are placed in a beaker, and a few drops of alcoholic solution of phenophthalein 1 per cent. added as an indicator; titration with a decinormal solution of sodium hydrate is then carried out in exactly the same way as previously described in the estimation of total acidity.

(*b*) Ten c.c. of the same gastric contents are placed in a beaker, and a watery solution of alizarin 1 per cent. (monosulphate of sodium) used as an indicator. One titrates with a decinormal solution as before. The end point is reached when the colour, which at first was yellow, turns to violet. Since alizarin does not act with proteid hydrochloric acid, the difference between (*a*) and (*b*) will indicate the amount of proteid hydrochloric acid.

(*c*) To ten c.c. of filtered gastric contents, an alcoholic solution of dimethyl-amido-azo-benzol 0·5 per cent. is added, and the

[1] *Loc. cit.*, p. 25.

mixture is titrated with one-tenth normal solution of sodium hydrate. This will give the quantity of free hydrochloric acid.

The difference between (*a*) and (*b*) + (*c*) will give the acidity referable to organic acids and acid salts.

This method of Töpfer is much more rapidly performed than that of Prout-Wynter, but it has the great disadvantage that the end colour with each titration is not sharply defined, and hence may lead to great personal variations.

It has been found, in a class of advanced students, that while the results obtained with the Prout-Wynter method tend to be more or less in accordance, those obtained with Töpfer's method seldom, if ever. agree.

If one individual, however, is carrying out a research, he becomes in time so skilled, and in his hands the end reaction is so sharp that he obtains, by means of the Töpfer method, correct results as compared with control experiments. In such a case, the method is accurate and useful for comparing different stomach analyses, but for those who only occasionally do quantitative stomach analyses, it is undoubtedly better to rely on the more tedious method of Prout-Wynter.

CHAPTER V

CHEMICAL EXAMINATION OF GASTRIC CONTENTS (*continued*)— LACTIC ACID, BUTYRIC ACID, ACETIC ACID

$$\textbf{LACTIC ACID}\text{—}\begin{array}{l} CH_3 \\ | \\ CH\,(OH) \\ | \\ COOH \end{array}$$

The recognition of lactic acid in the gastric contents is made by employing Uffelmann's reaction.

Chemical Test for Lactic Acid.—A few drops of perchloride of iron solution are added to a test-tube of water, so that the solution is so pale as to be almost colourless. The solution is then divided equally between two test-tubes, and to each tube one adds a few drops of 2 per cent. carbolic acid solution, which has for some time previously been exposed to the air, this rendering it more sensitive. The solution when ready for testing should be pale amethyst blue. One adds a few drops of filtered gastric contents to one of the test-tubes, when, in the presence of lactic acid, a marked yellow or greenish-yellow colour will be observed. This colour is easily recognised by comparing it with that of the control test-tube.

Since alcohol, sugar, and phosphates give Uffelmann's reaction, it is better to take five c.c. of gastric contents and shake them with thirty c.c. of pure ether, free from alcohol. The separated ether is then evaporated, and the residue dissolved in a little water, and tested with Uffelmann's reagent.

Quantitative Estimation of Lactic Acid (Boas's Method).[1]—" Ten c.c. of filtered gastric contents (which, in the case of free hydrochloric acid being present, must be evaporated to a syrup after the addition of barium carbonate) are taken, and a few drops of phosphoric acid added, the carbonic acid removed by boiling and the residue extracted on cooling with

1 Simon, " Clinical Diagnosis," p. 160.

100 c.c. of pure ether free from alcohol. The ether is evaporated after separation, and the residue shaken up with forty-five c.c of distilled water, and treated with sulphuric acid and manganese dioxide. The flask is closed by a doubly perforated stopper; through one aperture, a bent tube passes to the distilling apparatus, and a straight tube provided with a piece of rubber tubing clamped off through the other. The mixture is then distilled until about four-fifths of the contents have passed over, excessive heat being carefully avoided, or the aldehyde will be decomposed. The distillate is collected in an Erlenmeyer containing twenty c.c. of one-tenth normal solution of iodine, and mixed with twenty c.c. of 5·6 per cent. solution of potassium hydrate. The mixture, after being well shaken, is allowed to stand for a few minutes. In order to liberate the hypiodite and the iodine in combination with the potassium not used in the reaction, twenty c.c. of hydrochloric acid and an excess of sodium bicarbonate in substance (some of the latter should remain undissolved at the bottom), are added, and the excess of iodine determined by titration with one-tenth normal solution of sodium arsenite. The titration is carried to the point of decolourisation, when freshly prepared starch solution is added, and the mixture again titrated with one-tenth normal solution of iodine until the blue colour is permanent. The number of c.c. of one-tenth normal solution employed (*i.e.*, twenty), minus the number of c.c. of one tenth normal solution of sodium arsenite, will indicate the number of c.c. of the former required for the formation of iodoform, *i.e.*, the amount of lactic acid present in ten c.c. of gastric contents. As one c.c. of one-tenth normal solution of iodine has been found to indicate the presence of 0·003388 grams of lactic acid, it is only necessary to multiply the number of c.c. used by this figure and the result by ten, in order to obtain the percentage."

According to numerous observers, this method of Boas is sufficiently accurate for clinical purposes, but we have found it too tedious for general use.

The presence of lactic acid in the gastric contents after the usual test meals is of little importance clinically, since the lactic acid may be produced by the action of bacteria in the mouth, or even be preformed in the diet. It will be found that lactic acid is present in small quantities after all ordinary test meals, so that if one wishes to examine especially for this substance in the gastric contents, it is necessary to go through a special technique.

The stomach having been previously washed out, the patient is given a Boas meal of oatmeal soup, and one or two hours later, the stomach contents are obtained by means of the stomach-tube. The gastric contents under normal conditions will be found, under these circumstances, to give no reaction with Uffelmann's reagent. If lactic acid is present, one gets a very distinct reaction, and it has been shown by Boas that the Uffelmann reaction only occurs in cases of carcinoma of the stomach. The presence of lactic acid after the oatmeal diet in carcinoma of the stomach is due to the fact that the lactic acid bacillus is present. The question of why carcinoma should cause the presence of the lactic acid bacillus has not, up to the present, been satisfactorily settled. The clinical importance, however, is very great, as anything which helps to recognise carcinoma of the stomach in its early stages—when one may hope to do some good by surgery—is very valuable, and it is considered that lactic acid is present in the very early stages of carcinoma of the stomach, before the disease can be recognised by any other means.

$$\text{BUTYRIC ACID}—\begin{array}{l}CH_3\\ |\\ (CH_2)_2\\ |\\ COOH\end{array}$$

Increased fermentation occurs in the stomach whenever there is stagnation of the gastric contents, and in these cases one finds butyric acid.

For clinical purposes, it is, as a rule, sufficient to recognise the presence of butyric acid by the rancid, butter-like odour of the gastric contents.

Chemical Test for Butyric Acid.—An ethereal extract of gastric contents is obtained by shaking ten c.c. with an equal volume of ether, and slowly evaporating it in a glass capsule. After the disappearance of the ether, there will be left a few drops of water which have been extracted from the gastric contents. If necessary, a few more drops of distilled water may be added, and then some small pieces of calcium chloride. After well stirring the solution, one observes numerous oil-drops floating on the surface of the liquid, and these give off a characteristic odour of rancid butter.

The clinical significance of the presence of butyric acid corresponds to that of volatile acids, since it occurs, as already stated, where there is fermentation going on in the stomach, which is especially apt to take place where there is retention of the stomach contents for any length of time. In some cases one will find that the increase of butyric acid accounts for the marked acidity complained of by the patient, when there is no increase in the hydrochloric acid in the stomach contents.

ACETIC ACID— $\begin{array}{l} CH_3 \\ | \\ COOH \end{array}$

Amongst the volatile acids which may be present in cases of gastric stagnation, one has to include acetic acid.

Chemical Test for Acetic Acid.—Ten c.c. of gastric contents are shaken up with ether, and the ether pipetted off and filtered. The residue is shaken up with distilled water, and neutralised with a solution of sodium hydrate, when, on the addition of a drop of perchloride of iron, a dark red colour is obtained if acetic acid is present.

The presence of acetic acid has practically the same significance as that of butyric acid.

CHAPTER VI

CHEMICAL EXAMINATION OF GASTRIC CONTENTS (*continued*)—GASTRIC FERMENTS

THE gastric juice contains, under normal circumstances, three ferments—pepsin, rennin, and lipase.

Pepsin.—The most important of the three ferments present in the gastric contents is pepsin or its enzyme, pepsinogen.

Pepsin is recognised by its power, in the presence of free acids (more especially hydrochloric acid), of converting coagulated proteid into soluble albumen.

Coagulated Egg Albumen Test for Pepsin.—The white of a hard-boiled egg is cut into cubes of roughly 0·5 cm., which can be easily done with a double-bladed knife. Three test-tubes are prepared as follows:

(1) Four c.c. of filtered gastric contents.

(2) Two c.c. of filtered gastric contents and two c.c. of four per mille hydrochloric acid solution.

(3) Two c.c. of distilled water and two c.c. of four per mille hydrochloric acid solution.

Into each of these test-tubes is placed a cube of egg albumen, and the tubes are put into a thermostat or water-bath at 37° C. In the presence of pepsin of sufficient quantity, the whole of the proteid will be converted into soluble albumen in from half an hour to an hour, so that the fluid becomes quite clear in test-tubes Nos. 1 and 2. If the albumen has been properly coagulated, it will remain unaltered in test-tube No. 3, and this is the object of its use—as a control tube.

The gastric contents, when they contain an insufficient quantity of hydrochloric acid, or when only pro-enzyme is present, will only show digestion in test-tube No. 2, an additional quantity of hydrochloric acid having been added to make up for the deficiency of hydrochloric acid present In the case of pepsinogen only being present, the free hydrochloric acid which has been added has converted the pepsinogen into active pepsin.

Carmine-Red Fibrin Test.—Some fibrin from bullock's blood is quickly washed free from all traces of colouring-matter, this being important so as to avoid decomposition of the fibrin. The fibrin is then dried with alcohol and ether, and stained with an alcoholic solution of carmine-red until the colour does not deepen. Any excess of carmine is removed by washing in water, and the fibrin thus prepared is kept in glycerine.

Method of carrying out Test.—Three test-tubes are prepared as follows :

(1) Four c.c. of filtered gastric contents.

(2) Two c.c. of filtered gastric contents and two c.c. of a four per mille hydrochloric acid solution.

(3) Two c.c. of filtered gastric contents and two c.c. of distilled water.

A small piece of carmine fibrin which has been washed clear of glycerine is placed in each of the test-tubes, which are then placed in a water-bath at 37° C., being taken out and shaken every two or three minutes. The time when the fluid is first coloured by carmine is noted. Pepsin, in the presence of hydrochloric acid, dissolves the fibrin, converting it into soluble fibrin, thus liberating the carmine which becomes diffused through the fluid, and indicates that digestion has commenced.

If pepsin and hydrochloric acid are present in the gastric contents in normal amounts, it will be found that test-tube No. 1 will show a red colouration in from three to five minutes. In the event of the hydrochloric acid in the gastric contents being normal, the additional quantity of hydrochloric acid in test-tube No. 2 will tend to make it excessive, and thus hinder digestion.

In hypohydrochloria, or in cases where the proenzyme and not pepsin is present, test-tube No. 2 will show a red colouration before the other test-tubes.

In hyperhydrochloria, it will be found that test-tube No. 3, which has been diluted with water, will show distinct digestion of the fibrin before test-tubes Nos. 1 and 2, since the pepsin will not act as rapidly if hydrochloric acid is in excess in the gastric contents.

As examples of these three conditions, we will give three typical cases.

(A) **Euchlorhydria.**

(1) Red colouration in 3 to 5 minutes.
(2) Red colouration in 3 to 5 minutes.
(3) Red colouration in 5 to 10 minutes.

(B) **Hyperhydrochloria.**

(1) Red colouration in 7 to 15 minutes.
(2) Red colouration in 3 to 7 minutes.
(3) Red colouration in 3 to 12 minutes.

(C) **Hypohydrochloria.**

(1) Red colouration in 10 to 30 minutes.
(2) Red colouration in 5 to 30 minutes.
(3) Red colouration in 30 to 120 minutes.

In practice we find that this carmine fibrin test is easily carried out, and gives a great insight into the powers of digestion of the gastric contents. Another advantage is the fact that the fibrin can be prepared and kept for a long time, provided it is covered with plenty of glycerine.

Quantitative Estimation of Pepsin.—For the quantitative estimation of pepsin, more accurate methods are required than the foregoing digestive method.

Leube's Method.—Two test-tubes of filtered gastric contents are taken, and to each is added either carmine fibrin or egg albumen, and to one a little pepsin. If the proteid is more rapidly digested in the test-tube to which pepsin has been added, it shows that an insufficient quantity of pepsin is present in the gastric contents.

In some cases in which hydrochloric acid is absent from the gastric contents, the stomach appears to be excreting no pepsin, though in reality pepsin is present in the form of its enzyme, pepsinogen. Jaworsky[1] has recommended in such cases the introduction, into the stomach of the fasting individual, of 200 c.c. of one-tenth normal hydrochloric acid solution; half an hour later, the stomach contents are removed, and the fluid thus obtained tested for pepsin.

[1] *Zeitschr. f. Klin. Med.*, Bd. xi. p. 113.

Mett's Method of Estimating the Quantity of Pepsin.[1]—A solution of white of egg is sucked up into fine glass tubes of 1 to 2 mm. lumen, and quickly coagulated by plunging the tubes into hot water at 95° C. The tube thus prepared is cut into small lengths, and placed in one or two cm. of the fluid to be investigated. The whole is kept in a thermostat at 37° C. After the termination of ten hours, the length of the pieces of tube and that of the undigested remains in the proteid column is measured off by the aid of a millimetre scale, a microscope of low-magnifying power being employed. The difference gives the length of the digested proteid in millimetres and fractions of a millimetre. The quantity of pepsin is the square of the albumen column dissolved in the same time. If one of the fluids digests a column of 2 mm. of proteid, and the other a column of 3 mm., the relative quantity of pepsin in each is not expressed by the figures 2 and 3 respectively, but by the squares of these figures, *i.e.*, by 4 and 9. The second fluid is, therefore, two and a quarter times stronger than the first.

Rennet Ferment or Rennin.—The ferment next in importance to pepsin is rennin, the analysis of which has been very little utilised in the diagnosis of gastric diseases.

Hammarsten's Method.—Ten c.c. of unboiled milk of neutral reaction are placed in a capsule, adding one or two c.c. of previously filtered and neutralised gastric contents. It is necessary not to add too great a quantity of gastric contents, as the dilution of the milk may either hinder the rapidity or interfere with the proper coagulation. The mixture is kept at body temperature, and if rennin is present, the milk will in ten to twenty minutes be coagulated into a solid mass, without any alteration in its chemical reaction. If the milk has been too much diluted, there will be no firm clot even in the presence of rennin, but only masses of flocculi settled at the bottom of the vessel.

The diminution or absence of rennin in gastric catarrh has been shown by Boas and Bouveret[2] to demonstrate how far the gland tissue has been destroyed, and may be of value in

1 Pawlow's "The Work of the Digestive Glands" (translated by W. H. Thompson), 1902, p. 26.

2 *Gaz. Med. de Paris*, 1893, No. 22.

coming to a conclusion as to the degree of recovery one may expect in such cases from proper treatment. It is found that the quantity of rennin as a general rule rises and falls with the quantity of pepsin. Up to the present, most clinicians have been content with estimating the peptic action of the gastric contents, and have neglected the rennet ferment.

Lipase: Fat-splitting Ferment of the Stomach.—The normal stomach contains, in addition to pepsin and rennin, the ferment lipase, which is capable of breaking up neutral fat into fatty acids and glycerine. Some of the fat acids are then further saponified in the stomach.

Recognition of Lipase.—Some olive-oil is shaken up with sodium hydrate in a test-tube, and the oil decanted so that it has an alkaline reaction, since ordinary olive-oil generally contains some free fatty acids. Litmus solution or some other indicator is added to some of the neutral olive-oil in two test-tubes; to one of these some previously filtered and neutralised gastric contents are added, and to the other an equal quantity of water. The two test-tubes are then well shaken and placed in a water-bath at 37° C., the tubes being periodically shaken. If lipase is present, the test-tube containing the gastric contents and the olive-oil will gradually show an acid reaction by turning the litmus red. So far, no experiments have been done on the presence or absence of lipase in different diseases of the stomach.

CHAPTER VII

CHEMICAL EXAMINATION OF GASTRIC CONTENTS (*continued*)—GAS FERMENTATION IN STOMACH

UNDER normal conditions, a certain amount of air is swallowed with the food, and apparently some carbonic acid is given off from the blood-vessels of the stomach wall itself, while it is possible that some gas passes from the intestine through the pylorus into the stomach. The quantity of gas present in the stomach under ordinary circumstances is so small that it is unnoticed by the individual. The swallowing of gas, on the other hand, may cause the patient to eructate large quantities, this being especially seen in nervous eructation. In such cases, the air is swallowed either into the œsophagus or into the stomach itself, and later eructated with loud reports. This nervous eructation is one of the manifestations of a neurotic taint, and can be easily recognised by the facts that the repeated gas has neither taste nor odour, and that on placing a cork between the molars, the eructation ceases.

The gases found in the stomach are nitrogen, carbonic acid, oxygen, and sometimes, hydrogen, while under pathological conditions, sulphuretted hydrogen or marsh gas may occur. A rough analysis of the gases of the stomach can be easily carried out.

A eudiometer is filled with gastric contents, inverted over water—or better, mercury—and kept for twenty-four hours at 37° C. The gas which collects in the eudiometer can be first examined for carbonic acid by inserting a strong solution of sodium hydrate, and measuring what amount of gas has been absorbed. Some pyrogallic acid is then added, which will dissolve any oxygen present, and if necessary, the hydrogen can be estimated by sparking (after the addition of some pure oxygen), and the nitrogen estimated by the residue. Sulphuretted hydrogen can be recognised by inserting some lead acetate paper, which will become distinctly blackened if this gas is present.

The chemical examination of the gases of the stomach is of little importance for clinical purposes.

The formation of gas in the stomach, or gas reaching the stomach from the intestine, may be so much increased as to produce marked symptoms—sometimes becoming even the chief symptom complained of by the patient.

In pyloric stricture, owing to the putrefaction of the proteids in the stomach, one may obtain large quantities of sulphuretted hydrogen which may be very objectionable to the patient on account of the odour. As a pathological novelty which has several times been observed, a patient may eructate inflammable gas, and cases have been described whère patients have been able to ignite the eructated gas at the end of a cigar-holder. Boas [1] states that sulphuretted hydrogen is more often present in benign disease of the stomach, while, where there is gas formation due to malignant disease, it is almost invariably absent.

In some cases the patient eructates marsh gas, this gas being formed by the decomposition of the cellulose; but it is still a question whether it can be formed in the stomach itself, or whether—as seems more probable—it reaches the stomach from the intestines.

[1] *Deut. Med. Wochenschr.*, 1892, No. 49.

CHAPTER VIII

ORGANIC DISEASES OF THE STOMACH—ACUTE, CHRONIC AND ALCOHOLIC CATARRH, ACHYLIA GASTRICA

Gastric catarrh is very commonly diagnosed, and probably in practice many cases of functional disease of the stomach have been erroneously included under this heading.

True gastric catarrh is accompanied by structural changes in the stomach wall, so that one has an inflammatory process to deal with. In the mildest forms, it may be merely an inflammatory desquamation of the epithelium covering the mucous membrane of the stomach, while in more severe cases the inflammation extends into the glandular parenchyma. In even more advanced cases, it extends into the fibrous tissue of the stomach wall itself.

Gastric catarrh may, for the sake of convenience, be divided into acute and chronic, according to the intensity and duration of the disease, but it must be remembered that the dividing-line between the two is purely arbitrary.

The general symptoms of gastric catarrh have not here to be dealt with, but merely the alterations in the activity of the secretions of the stomach, as shown by the examination of the vomited matter, or more definitely and accurately determined by the analysis of the gastric contents after a test meal.

In the normal stomach, neither the vomited matter nor the gastric contents after a test meal contain mucus in any large quantity. Schüle[1] considers that mucus is present in the normal stomach on a carbohydrate diet, while Heidenhain has shown that mucus only occurs in very small quantities in carnivora, and in larger quantities, in herbivora.

The normal quantity of mucus present in a healthy stomach cannot be easily recognised in the gastric contents obtained after an ordinary test breakfast. Where there is a diminution

[1] *Zeitschr. f. Klin. Med.*, Bd. xxviii. p. 481.

of hydrochloric acid, Schmidt[1] has shown that one finds glassy swollen lumps resembling saliva, while, if hydrochloric acid is present in normal, or even increased quantities, the mucus has a filamentous, flocculent, or shreddy appearance. It has been shown that mucus takes twice the time for digestion that an equal quantity of albumen requires.

It is necessary to make certain that the mucus found in the stomach contents really comes from the stomach, and not from the other passages. The mucus from the back of the pharynx or nares can easily be recognised by its darkened colour, being stained more or less by carbon in town-dwellers, while that coming from the saliva will be found, not intimately mixed with the gastric contents, but distinctly separate. In all cases of gastric catarrh, one will find more mucus than the mere trace found in a healthy stomach, and much more than is found in any other stomach disease, except possibly mucoid gastritis, (if it is considered desirable to separate this from the ordinary chronic gastritis). In the majority of cases of gastritis, one may expect to find the gastric secretions—with the exception of mucin—to be decreased, the ferments being also decreased. When atrophy of the mucous membrane has set in, not only hydrochloric acid, but also ferments, entirely disappear from the gastric contents. In consequence of the decrease of hydrochloric acid and pepsin in cases of gastric catarrh, the proteid digestion is diminished. In most cases of catarrh, hydrochloric acid is not entirely absent, and there is a small quantity of pepsin present, which explains the partially digested food in the vomit; the digestion of starch taken in the diet is little, if at all, interfered with. As already stated, the excretion of rennet ferment, as a rule, runs parallel with that of hydrochloric acid and pepsin, and, according to Boas and Bouveret,[2] the quantity of rennin present in gastric catarrh is of very great clinical importance in deciding the intensity and prognosis of the disease. The organic acids tend to be slightly increased in cases of catarrh of the stomach, and these acids are very considerably increased when, in addition to the catarrh, one has some stagnation of the gastric contents. In hardly any cases of simple catarrh of the stomach is there a large quantity of lactic acid found, though

1 *Deutsch. Archiv. Klin. Med.*, vol. lvii. p. 72.
2 *Loc. cit.* p. 39.

there is considerable increase of butyric and other fatty acids; and this distinguishes simple catarrh of the stomach from catarrh accompanying malignant disease of the stomach.

ACUTE GASTRITIS

The vomit in acute gastritis consists of undigested residue of food mixed with mucus, and often has an unpleasant taste, even when the emesis does not occur until some hours after the last meal. If the vomiting has been frequent, the residue of food becomes less and less, until the later vomits may consist entirely of mucus, more or less bile-stained.

The chemical examination of the vomit in acute gastritis shows an acid reaction, although the total acidity is never very high; and in cases where there has been frequent vomiting, the later vomits may be neutral, or even faintly alkaline. The tests for free hydrochloric acid, as a rule, are negative, although one sometimes obtains a feeble reaction. On the other hand, the organic acids, more especially butyric and acetic acids, will be found to be increased. Bile is often present, and when the emesis has been frequent the vomit may contain merely bile-stained mucus, which gives a very distinct reaction with cold nitric acid for bile pigments.

Blood in small quantities is not uncommonly found in acute gastric catarrh. The gastric juice, by its action on the hæmoglobin, has, however, generally converted most of the blood present into hæmatin, and when only small quantities are present, it may be impossible to recognise it without chemical means. If some of the brown mass is collected in a pipette, and dissolved in sodium hydrate, after filtration and the addition of ammonium sulphide, it can be examined by the spectroscope for hæmochromogen, when, in an alkaline solution, one obtains two absorption bands—a marked band between D and E (556·4 wave length), and the second band, which is not so dark, between E and b (520·4 wave length).

The first severe symptoms having passed off, a more thorough analysis of the alterations in the gastric secretions can be obtained after the administration of a test breakfast. The toast appears very little altered, and looks as if it had been simply swallowed, mixed with a certain amount of mucus.

The breaking up of particles of food in the healthy stomach is in great part due to the churning movements of the stomach wall, by means of which the gastric secretions are intimately mixed with any solid contents, the mechanical action at the same time kneading the contents into a homogeneous consistency. In acute catarrh of the stomach, there is a deficiency of both the gastric secretions and motor-power of the stomach wall—hence the appearance of the gastric contents.

TABLE II.—ANALYSIS OF GASTRIC CONTENTS IN ACUTE GASTRIC CATARRH

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).		
								HCl.						
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	Total.	Free.	Proteid.	Mineral.	1	2	3
C. 55	acid	0	+	+	+	24	7	0·16	0·00	0·02	0·14	0	0	0
F. 60	acid	0	+	+	+	30	7	0·19	0·00	0·04	0·15	10	4	15
W. 89	acid	0	+	+	+	44	11	0·28	0·00	0·18	0·10	0	0	0

(*a*) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(*b*) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

In Table II. the analysis after a test breakfast of three cases of acute gastric catarrh is given. In these three cases it so happens that the reaction is acid, although it is not uncommon to find it neutral.

Qualitative Analysis.—The chemical tests for free hydrochloric acid gave no reaction in any of the three cases, which is what is to be expected in acute gastritis, though one occasionally obtains a trace.

Lactic acid is, as a rule, found to be present where the ordinary test breakfast has been given, and it is essential to give Boas's oatmeal soup if one wishes to compare the results with what will be found in cases of carcinoma of the stomach. Butyric acid was present in the three cases given above, and this is the general rule, although we have sometimes known it absent.

Mucus is found to be present in considerable quantities; in some cases it is extremely frothy, and the gastric contents contain bubbles in the mucus, while on other occasions, one finds not so much gas, though the mucus is always intimately mixed throughout the fluid.

Quantitative Analysis.—The total acidity will be found after test breakfasts to be always, comparatively speaking, low, varying in the three cases which we have given as types from 24 to 44.

The volatile acids are, as a rule, increased, varying from 5 to 15, while in the cases we have given, they vary from 7 to 11. In cases of acute gastric catarrh, where there are complications, such as pyloric obstruction with considerable stagnation of the gastric contents, the volatile acids may be very much higher than these figures.

Quantitative Analysis of Hydrochloric Acid.—The Prout-Wynter method shows that the total quantity of hydrochloric acid varies from 0·16 to 0·28 per cent., the tendency being towards the lower figure. In the three cases we have used as types, free hydrochloric acid was absent, and if present, the quantities will be extremely small. Hydrochloric acid combined with proteids is seen in the first two of these cases to be low, 0·02 and 0·04 per cent., and only in the last case, where there is the highest total acidity, does the proteid acidity reach 0·18 per cent. The chlorine combined with the minerals is large in amount in the first two cases, 0·14 and 0·15 per cent., while in the last case, where the total hydrochloric acid was found to be highest, it is 0·10 per cent. In fact, in the first two analyses, nearly all the chlorine present in the stomach contents is combined with the minerals.

Digestion.—One at once obtains a clue as to the presence or absence of pepsin or pepsinogen in making digestive tests with carmine fibrin. In two of the cases given, we find that there is no digestion of the fibrin in any of the tubes even up to the lapse of thirty minutes, so that we can say that neither pepsin nor pepsinogen was present in these two cases. In the other case, test-tube No. 1 (containing gastric contents and fibrin alone), showed the first signs of digestion after ten minutes, while test-tube No. 2 (containing gastric contents and an equal quantity of four per mille hydrochloric acid) showed the first appearance of digestion in four minutes. In test-tube No. 3 (to which an equal quantity of water was added), digestion was delayed for fifteen minutes. It is seen that in this case the hydrochloric acid was diminished, and digestion did not occur at all rapidly except with the addition of hydrochloric acid; but since digestion did occur in test-tubes 1 and 3 after a certain length of time, pepsin was present as pepsin and not only as pepsinogen, the delayed digestion being entirely due to the lack of hydrochloric acid. The fact that in the case in which most hydrochloric acid was present there was no digestion with the fibrin test, is of interest, as it shows that neither pepsin nor pepsinogen were present. In this case the analysis was carried out during an attack of acute catarrh in a patient who was probably suffering from chronic alcoholic catarrh; hence the difference of analytical results in this case from the first two, in which there was only simple acute gastric catarrh.

CHRONIC GASTRITIS

The quantity of the vomit in chronic gastritis is never very large, and considering the regularity of the vomiting, is quite remarkable for its smallness. In severe cases, one finds remnants of undigested food looking as if they had been simply swallowed; the particles are intimately mixed with mucus, so that the thick slimy gastric contents can only with great difficulty be poured from one vessel to another, and in some cases where the vomit is very small in amount, it will adhere so firmly to the vessel that the latter can be turned upside down without upsetting the contents. The mucus produced in the stomach is always intimately mixed with the fluid together with some balls or flakes, while the mucus coming from the mouth, pharynx, or nares floats in stringy masses in the gastric contents. Only in washing out an empty stomach does one find, in chronic gastritis, flocculi of mucus which have been washed away from the stomach wall, and deposited at the bottom of the vessel receiving the wash-water. Not only is the examination of the gastric contents after a test meal of importance in chronic gastritis, but it is well also to examine the morning vomit or the water used in washing out the fasting stomach. This will be found to be rich in mucus, with a feebly acid or neutral reaction, as a rule containing no free hydrochloric acid.

The microscopic examination of the vomit may reveal numerous epithelial cells and nuclei mixed up in the mucus, and, in some cases, fragments of gland tissue may be found. Einhorn[1] lays great stress on the presence of small particles of mucous membrane in the wash-water, which are not due to any injury produced by the stomach-tube, but are the products of a special form of catarrh of the stomach accompanied by erosion. In some cases one finds pus on microscopic examination, and it is important to consider whether the stomach itself is the source. In severe infectious diseases, such as puerperal fever, empyema, &c., it is possible that interstitial purulent inflammation of the stomach may be present; still further, where a tumour has been felt in the region of the stomach and has become smaller or disappeared, one may have to deal with gastric abscess or perforation of an abscess, or perforation of an abscess from some neighbouring viscus into the stomach.

In cases of chronic gastric catarrh, there is often a certain amount of diminished motility, which will produce objective signs in the vomit or test meal, such as the remains of former meals. In rare cases one gets increased motility, causing the ingesta to pass on to the intestine in a shorter period than normal. In such cases, on passing the tube at the ordinary time after a test meal, the stomach will be found to be empty.

The quantity of gastric contents after a test breakfast will be found to vary very much, according to whether there is delayed motility or not. In the five cases which we have taken in Table III. to illustrate the condition, the quantity varied from 70 to 200 c.c.; the general tendency, however, is for the quantity to be small.

The reaction in most cases will be found to be feebly acid, although on occasion it may be neutral (such cases have not come under our observation).

Qualitative Analysis.—The test for free hydrochloric acid gives, as a rule, a very feeble reaction, and generally fails, as in three of the cases given.

If Boas's oatmeal soup has been given, lactic acid is absent, or in any case, will be very small in amount. This is of great importance when we consider that many chronic gastric catarrhs yield chemical analyses very closely resembling those of catarrh

[1] Einhorn, "Diseases of the Stomach," 2nd edit. 1898.

accompanying carcinoma of the stomach; while in the latter, the presence of excessive quantities of lactic acid will help to confirm the diagnosis, the absence or small quantity of lactic acid will enable one to recognise a case of simple chronic gastric catarrh.

TABLE III.—ANALYSIS OF GASTRIC CONTENTS IN CHRONIC GASTRIC CATARRH

Case.	Qualitative.					Quantitative.						Digestion in minutes (*b*).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (*a*).	Volatile acid (*a*).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3
H. R. 3	acid	0	+	+	++	22	16·6	0·17	0·01	0·08	0·08	0	17	0
C. 30	acid	0	+	+	+	45	5·2	0·15	0·00	0·05	0·10	0	15	0
P. 38	acid	+	—	+	+	54	11	0·25	0·01	0·17	0·07	12	10	0
D. 71	acid	+	—	+	+	54	6	0·25	Trace	0·18	0·07	14	3	17
U. 79	acid	0	—	+	++	20	11	0·26	0·00	0·06	0·20	0	22	

(*a*) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(*b*) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

In most cases of chronic gastric catarrh, butyric acid is found to be present in the stomach, sometimes in fairly large amounts.

In all cases, as has already been stated, mucus in excessive quantity is found.

Quantitative Analysis.—The total acidity varies from 20 to 54 in the cases which we have chosen as examples; the tendency is to be low, and when one considers how much of this acidity is due to volatile acids, one sees that the total quantity of hydrochloric acid and acid phosphates is very small indeed.

The volatile acids are increased, varying from 5·2 to 16·6: where there is delayed motility, a larger quantity of volatile acids is generally found.

Quantitative Analysis of Hydrochloric Acid.—The total hydrochloric acid, as estimated by the Prout-Wynter method, is low, varying from 0·15 to 0·26 per cent. Free hydrochloric acid is, as a rule, not present, although it may be as much as 0·01 per cent. The general tendency in cases of chronic gastric catarrh is for the hydrochloric acid combined with the proteids to be extremely low (although not so much so as is found in acute catarrh), the amounts varying between 0·05 and 0·18 per cent. The chlorine combined with the minerals is not found to be increased, varying from 0·07 to 0·10 per cent., and only in one case is it as high as 0·20 per cent.

Digestion.—The carmine fibrin test shows the digestive powers in all cases to be decreased; in the majority of cases, there is no digestion whatever of carmine fibrin, except with the addition of four per mille hydrochloric acid. In two of the examples which we have taken for illustration, there was digestion in twelve to fourteen minutes, and with the gastric contents alone. There was no digestion in test-tube No. 3 (in which the gastric contents were diluted with water), except in one case where there were signs of digestion after seventeen minutes. In the cases which we have taken as types, we find the digestion in test-tube No. 2 (to which four per mille hydrochloric acid was added), to vary from three to twenty-two minutes. It would, therefore, appear that in all these cases either pepsin or pepsinogen was present, although in some cases of chronic gastric catarrh—more especially those which have advanced very considerably—even pepsinogen may be absent, and in these cases, rennin will also be absent.

Further examination of these cases showed that in one case blood in small amount was present (being only identified by chemical means), and the microscopic examination showed, in some cases, masses of epithelial cells entangled in mucus.

ALCOHOLIC CATARRH

We can now discuss four cases of chronic catarrh in alcoholic subjects. These are of interest as showing analyses differing from those of ordinary catarrh, and if further observers confirm these results, they will be of value in helping to diagnose chronic gastric catarrh of alcoholic origin.

The quantity of gastric contents in these four cases, *see* Table IV., was small, as one finds in ordinary catarrh.

The reaction in all cases was acid.

Qualitative Analysis.—Free hydrochloric acid was found to be present, giving a distinct reaction.

The volatile acids, acetic and butyric, were found to be increased. Lactic acid was not especially sought for by Boas's oatmeal soup, but butyric acid was very evident by the odour and was also demonstrated by chemical tests.

As in all cases of ordinary gastric catarrh, mucus was present; but in these cases it seemed to be thicker and of a more tenacious consistency than is found in simple catarrhs.

TABLE IV.—ANALYSIS OF GASTRIC CONTENTS IN ALCOHOLIC CATARRH

Case.	Qualitative.					Quantitative.						Digestion in minutes (*b*).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (*a*).	Volatile acid (*a*).	HCl.						
								Total.	Free.	Proteid.	Mineral.	1	2	3
P. 24	acid	+	—	+	++	88	11	0·32	0·02	0·15	0·15	7	5	8
R. 36	acid	+	—	+	++	76	16	0·27	0·02	0·18	0·07	5	5	8
G. 91	acid	+	—	+	++	88	12	0·37	0·02	0·26	0·09	5	8	4
H. 95	acid	+	—	+	+	77	7	0·36	0·01	0·25	0·10	13	12	15

(*a*) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(*b*) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

Quantitative Analysis.—The total acidity varied from 76 to 88, showing a distinct increase, even when one compares it with the normal gastric contents, the increase being more marked in comparison with the total acidity which one finds in simple chronic catarrh.

The volatile acids varied from 7 to 16, showing an increased fermentation in the stomach.

Quantitative Analysis of Hydrochloric Acid.—The total quantity of hydrochloric acid varied in the four cases from 0·27 to 0·37 per cent., corresponding with what one usually finds in the analysis of normal gastric contents. The qualitative analysis for free hydrochloric acid gave a distinct reaction, and the quantitative analysis of all the cases indicated the figure 0·02 per cent., except one (0·01 per cent.), a peculiar coincidence, showing only a very slight decrease from the quantity of free hydrochloric acid one usually finds in health after a test breakfast. The quantity of chlorine combined with proteids varied from 0·15 to 0·26 per cent., resembling the quantity of proteid hydrochloric acid found in healthy individuals, and which we have found in cases of ordinary gastric catarrh. The quantity of chlorine combined with the minerals varied from 0·07 to 0·15 per cent.

Digestion.—In three of the four cases one sees that the digestion was fairly rapid, in fact, two of the test-tubes showed digestion well within normal limits, and from the results obtained by the digestion of fibrin alone, one certainly would not be able to detect the presence of any pathological condition. In one case the digestion was distinctly delayed, and in test-tube No. 2, even after the addition of four per mille hydrochloric acid, it took twelve minutes as against tube No. 1 with gastric contents alone, which required thirteen minutes. So one sees that the delayed digestion is not due to pepsinogen only being present, but to a decrease in the activity of the pepsin. This case is of especial interest as it occurred in a beer taster.

It would appear that in chronic gastric catarrh of alcoholic origin, there is a greater proportion of mucus than can be accounted for by the diminution in the quantity of gastric secretion, as indicated by the quantity of hydrochloric acid or pepsin. We have a tendency to mucus catarrh, if one is to consider that such a thing exists, and if there is destruction of the glandular cells in the stomach in alcoholic catarrh, it would appear that the active cells secrete hydrochloric acid and pepsin to an excessive degree. One can consider that in alcoholic catarrh there is, in addition to the catarrhal process going on in the stomach, a hyperhydrochloria which accounts for the results obtained by analysis.

ACHYLIA GASTRICA

Chronic gastric catarrh may be completely cured or may slowly pass, with destruction of the glandular elements of the mucous membrane, into atrophy of the stomach. Fenwick[1] considered that there is a form of atrophy of the stomach as a disease—*sui generis*—leading to a condition very much resembling pernicious anæmia. Einhorn[2] states that the microscopic examination of the *débris* found in the wash-water

[1] *Lancet*, 1877. [2] "Diseases of the Stomach," 2nd edit. 1898.

of cases of achylia gastrica reveals portions of mucous membrane with some normal glands still present. He describes a case which lasted for five years, and then slowly recovered; the secretory acidity increasing so that the food was more or less digested, and hydrochloric acid gradually appearing in the gastric contents. He attributes this case of achylia gastrica, not to total absence of the gastric secretory glands, but to nervous disturbance, inhibiting for the time being the secretion of both hydrochloric acid and pepsin.

The gastric contents, after a test breakfast, have a brownish-white colour, and on standing, quickly separate into two layers, the upper an almost colourless fluid, and the lower a brown mass of solid particles of food, the toast being distinctly irregular in shape, and appearing not to have been acted on by digestion. There is very little finely divided material such as one finds in healthy gastric contents after a test breakfast, and as a rule,

TABLE V.—ANALYSIS OF GASTRIC CONTENTS IN ACHYLIA GASTRICA

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3
T. 49	acid	0	0	0	0	15	3·6	—	—	—	—	0	0	0
C. 49	acid	0	+	+	+	40	—	0·15	0·00	0·07	0·08	0	0	0
M. 66	acid	trace	0	0	+	40	6	0·10	0·00	0·03	0·07	30	20	0

(a) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(b) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

there is no increase in the quantity of mucus. The odour is not at all unpleasant, resembling in fact the food before it was introduced into the stomach.

In the above table we have given three cases, illustrative of achylia gastrica. The first is a typical case of the condition, which was verified by post-mortem three years later. The last case, although the analysis is not entirely in favour of achylia gastrica, has been included because the blood examination in this patient showed results exactly similar to those one finds in pernicious anæmia, and therefore the case ought to be included in this group.

The reaction in most cases will be found to be very feebly acid.

Qualitative Analysis.—In typical cases of achylia gastrica no reaction for free hydrochloric acid will be obtained, although in the third case given above, the analysis showed a trace of hydrochloric acid; in two previous analyses, however, of the same individual, no free hydrochloric acid had been found.

As a general rule the volatile acids are found not to be increased unless there is delayed motility. Lactic acid, if present at all, will be found only in traces. This is an important factor in distinguishing achylia gastrica from carcinoma. In both conditions we have a diminution or possible absence of hydrochloric acid, but in malignant disease, one finds lactic acid in increased quantities, whereas in achylia gastrica it is usually absent, or only present in traces. Of the three examples, lactic acid was only found to be present in one—after Boas's oatmeal soup.

Butyric acid appears to be, as a rule, absent, and is only present in one of the three cases in our table.

Mucus, if present, is intimately mixed with the food, and occasionally one sees long stringy masses which come from the posterior nares or back of the throat. It should be remembered that these patients often suffer from relaxed throats, and in noting the amount of mucus present in the gastric contents, this fact should be borne in mind.

Quantitative Analysis.—The total acidity will be found to be decreased. In cases where the condition has advanced to complete atrophy of the mucous membrane of the stomach, the total acidity may be as low as 4. In the case which was verified at the autopsy, the total acidity was found to vary from 10 to 16, and in the analysis given it was 15; in the other two cases in which the disease was not so advanced, it was 40.

In achylia gastrica, the quantity of volatile acids is not, as a rule, increased. In some cases, accompanied by dilatation of the stomach, there may be an increase of volatile acids, but even this would appear to be of rare occurrence.

Quantitative Analysis of Hydrochloric Acid.—The Prout-Wynter method shows either total absence of hydrochloric acid in all its forms, or marked diminution.

Unfortunately, in the case which was verified by post-mortem later, a quantitative analysis was not done; in the other two cases we see that the total quantity of hydrochloric acid varied from 0·10 to 0·15 per cent. Free hydrochloric acid was absent in both cases, and the proteid hydrochloric acid was in one case only 0·03, while in the other it was 0·07 per cent.

The chlorine combined with the minerals was very low, being 0·07 and 0·08 per cent.

Digestion.—The carmine fibrin test showed, in the first and second cases, a total absence of pepsin and pepsinogen. In the third case, there was only very slight digestion in thirty minutes in the test-tube containing gastric contents and fibrin alone, while on the addition of four per mille hydrochloric acid, there was digestion after twenty minutes. From the chemical analysis alone, one might at first consider that this was a case of malignant disease of the stomach, although against such a diagnosis was the fact that the volatile acids were only slightly increased, and still further, in three separate analyses, lactic acid was absent. The general symptoms of the patient and a more detailed examination of the urine and blood indicated pernicious anæmia, while the fact that he lived for five years after the analysis shows the importance of taking into account all the symptoms and other methods of diagnosis, since from the chemical analysis of the stomach contents alone, a diagnosis of carcinoma of the stomach *might* have been made.

The motor-power of the stomach is, as a rule, normal. In the first case after Riegel's test meal, the stomach was found to be completely empty between the fourth and fifth hours, and this patient suffered as a rule from no symptoms of indigestion, except occasionally from flatulency.

On washing out a fasting stomach in an individual suffering from achylia gastrica, it is not uncommon to find traces of blood or particles of mucous membrane, showing that the stomach walls are more easily wounded by the stomach-tube than in health, and this was especially marked in the first case tabulated. Schmidt[1] and Riegel[2] state that large quantities of mucus may be present in cases of achylia gastrica, but in the cases which have come under our observation, this has not been confirmed.

1 *Deut. Arch. f. Klin. Med.*, vol. lvii.

2 *Die Erkrankungen des Magens*, 1897, p. 616.

CHAPTER IX

ORGANIC DISEASES OF THE STOMACH (*continued*)—GASTRIC ULCER

The symptoms of pain and vomiting in gastric ulcer, although not strictly chemical, are of such importance as to necessitate a few remarks before discussing the chemical analysis.

The typical pain of gastric ulcer is commonly supposed to occur immediately after the food has been taken, while in practice it is found that the pain occurs at various times; it may be immediately after food, or it may be delayed for two or three hours. Numerous cases of undoubted gastric ulcer occur, in which the first symptom is the vomiting of blood without any pain, and therefore pain can only be considered as one of many symptoms of ulceration of the stomach.

There is a tendency for the emesis to occur at the height of the pain, whether it occurs immediately or two or three hours after the ingestion of food, and unlike the emesis which occurs in hyperhydrochloria, the vomiting causes almost immediate relief. The vomiting in gastric hypersecretion, occurring as it does at irregular intervals, and that of gastric ulcer occurring at a more or less constant interval after the taking of food in each special case, helps to differentiate these conditions, in spite of the similar chemical analyses.

The vomit in cases of gastric ulcer shows a different appearance according to the quantity of food or the period of time which has elapsed since it was taken. The longer the interval between the taking of the food and the vomiting, the better digested the stomach contents appear to be, the food often being very finely broken up, thus indicating a good motility as well as an active secretion. The vomit has a very acid taste, so that the patient may complain of the sourness.

Hæmatemesis is of so great importance in the diagnosis of gastric ulcer that one may regard it as the most important sign, and unless it is present, or the history of a previous hæmorrhage has been obtained, it is difficult to diagnose a case as one of gastric ulcer. We must remember that the finding of blood, even in comparatively large quantities, is not invariably a sign of gastric ulcer, as it may be due to circulatory changes either in the stomach wall itself or the lower end of the œsophagus, such as one finds in cirrhosis of the liver.

Blood, when present in large quantities in the vomit, may have a normal bright red appearance, while if in small quantities, or if it has been retained in the stomach for some time after the hæmorrhage has occurred, one gets the well-known coffee-ground appearance. And in the latter case it may sometimes be necessary to make a chemical analysis in order to recognise that it is blood. Blood in gastric ulcer is, as a rule, present in more or less large quantities, the hæmorrhage being generally accompanied or preceded by some pain; in a few cases, however, as already mentioned, there may be hæmorrhage without any previous symptoms to lead one to suspect the possibility of ulceration.

The total acidity of the vomited matter is generally increased, and the tests for free hydrochloric acid give a very marked reaction. When vomiting occurs immediately after the food is taken, the hydrochloric acid is naturally not so much increased, but even in these cases one obtains a reaction. Gastro-succhorea not infrequently occurs with gastric ulcer, and may possibly explain the reaction for free hydrochloric acid immediately after the taking of food.

It is generally considered that the stomach-tube should not be employed in cases of gastric ulcer, and it should not, as a rule, be used immediately after a hæmorrhage has occurred, although in some cases of repeated hæmorrhage the washing-out of the stomach may be of great service. Possibly it is better not to use it at all if a diagnosis can be made without it, but in doubtful cases it would appear that there is little objection to using it, provided ordinary care is taken. The chances of injury are small, and there is certainly less danger of injury being occasioned by a soft rubber tube than by the violent retching caused by vomiting.

The stomach contents after a test breakfast—unless the ulcer is situated at the pyloric end of the stomach, causing dilatation of that organ—are not at all large in quantity.

In all cases a distinctly acid reaction is present.

Qualitative Analysis.—The test for free hydrochloric acid shows an unmistakable reaction, enabling one at once to recognise that it is present, and in the majority of cases, the test alone will indicate that it is in excess.

TABLE VI.—ANALYSIS OF GASTRIC CONTENTS IN GASTRIC ULCER

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	HCl. Total.	Free.	Proteid.	Mineral.	1	2	3
H. 15	acid	+	0	0	0	64	13·6	0·28	0·01	0·18	0·09	5	4	6
H. 28	marked acid	++	0	0	0	94	3	0·42	0·02	0·29	0·11	4	4	4
F. 45	acid	+	—	+	+	118	15	0·40	0·12	0·20	0·08	2	4	2
E. 76	acid	+	—	+	+	88	.6	0·40	0·04	0·28	0·08	2	2	2
H. 102	acid	++	+	+	0	87	6	0·42	0·04	0·32	0·06	10	7	5

(a) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(b) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

The absence or presence of lactic acid in cases of gastric ulcer seems of little importance. If Boas's oatmeal soup has been given, lactic acid will not be present, though after an ordinary test breakfast, a reaction may be obtained. Butyric acid is, as a rule, absent, but in some cases—especially where dilatation of the stomach accompanies the ulceration—one may obtain a reaction.

As a rule mucus is not present in gastric ulcer, although in some few cases it may be found ; it is never, however, present in anything like the quantity accompanying gastric catarrh. The cases in which mucus does occur can also be easily distinguished from gastric catarrh by the high total acidity which occurs in gastric ulcer.

Quantitative Analysis.—In all cases where ulceration of the stomach has been found to be active—as in the cases in the above table which have been demonstrated by operation during the process of a gastro-enterostonomy—the total acidity is found to be high, varying from 87 to 118. In one case, in which the gastric ulcer was latent, it is only 64; unfortunately this case was not confirmed by operation, but hæmorrhage and other symptoms of gastric ulcer had preceded the analysis.

The volatile acids as a rule are very slightly increased, although in some cases where there is dilatation of the stomach, there is a marked excess, as in two of the cases given above, which were 13·6 and 15 respectively. In the other cases, the volatile acidity is seen to vary from 3 to 6.

Quantitative Analysis of Hydrochloric Acid.—In all the cases of gastric ulcer which were confirmed by operation, hydrochloric acid is present in large quantities. In the four certain cases we find from 0·40 to 0·42 per cent., while in the case in which no operation was performed, and the last hæmorrhage had occurred one month previously, the hydrochloric acid was only 0·28 per cent. Free hydrochloric acid is always present, and in the cases above given it varies from 0·01 to 0·12 per cent. The quantity of hydrochloric acid combined with proteids shows a considerable increase, the variations in the above cases being from 0·20 to 0·32 per cent.; only in the exceptional case is it less, 0·18 per cent. The general tendency appears for the chlorine combined with the minerals to be, comparatively speaking, low; in the above cases it varies from 0·06 to 0·11 per cent.

Digestion.—The carmine fibrin test in cases of gastric ulcer shows a tendency to increased rapidity of digestion. This is generally more marked in the test-tube containing gastric juice alone than in the tube to which four per mille hydrochloric acid has been added; the additional hydrochloric acid tending to hinder rather than to increase digestion. In the cases given as examples, it will be noted that the digestion is sometimes apparent in two minutes, and in only one case was it as slow as ten minutes in the test-tube containing gastric juice alone. In this latter case, the digestion, when hydrochloric acid was added, was more rapid, taking only seven minutes. The tube to which water had been added digested in five minutes; the explanation is difficult to give. In the other cases, it is seen that the dilution with water did not cause very marked alterations in the activity of the pepsin.

In cases of gastric ulcer where a Riegel's test meal has been given, one finds the stomach empty in a normal period, and it is not at all uncommon to find after a test breakfast the stomach almost empty in the space of one hour, so that it would appear that in some cases of gastric ulcer, especially when the ulceration does not occur towards the pyloric end of the stomach, there is a tendency to increased motility.

CHAPTER X

ORGANIC DISEASES OF THE STOMACH (*continued*)— GASTRIC CARCINOMA

In malignant disease of the stomach, the situation of the growth gives rise to certain characteristic symptoms which are indicated in the gastric contents. In carcinoma of the cardiac end of the stomach, when the growth has increased so as to cause stenosis, true vomiting does not occur, but one sees regurgitation of food, mixed with large quantities of mucus which accumulate in the lower end of the œsophagus immediately above the narrowing. The vomit in these cases occurs with great regularity, and as a rule, immediately after the taking of food. In such cases, the position of the growth can be demonstrated by means of the stomach-tube, and portions of the growth are occasionally found in the eye of the tube; these will be invaluable in making a diagnosis by microscopic examination. The examination of the patient by X-rays is of very great service, especially if milk containing bismuth sub-nitrate has been given, and its passage watched along the œsophagus.

In carcinoma of the pyloric end of the stomach, when the growth has advanced so far as to cause narrowing of the pylorus, so that the gastric contents can only with difficulty pass into the duodenum, dilatation of the stomach is gradually produced, and it is not at all uncommon to see distinct peristaltic waves on inspection of the patient's abdomen. The vomiting in such cases is very obstinate, occurring every few days, or sometimes daily, and as time goes on the periods between the vomiting diminish in length. It is found that in pyloric carcinoma, the vomiting usually occurs in the afternoon or evening, thus distinguishing it from the vomiting of simple gastric catarrh, which, as a rule, occurs in the early morning. The quantity of vomited matter in pyloric carcinoma is as a rule large, from half to one litre, which also distinguishes it from gastric catarrh, where a small quantity of vomited matter is noted. The vomit consists mostly of food in an undigested or semi-digested condition, and often the remnants of the food of previous days.

Carcinoma of the stomach may exist for long periods without any vomiting, and this is especially apt to occur when the smaller or larger curvature or posterior wall of the stomach are involved in the malignant growth. In some cases where there has been frequent vomiting, and carcinoma either of the cardiac end of the stomach, or the lower portion of the œsophagus, has caused such constriction that not even the finest stomach-tube can be passed, the passage will suddenly become free and the vomiting cease. This is due to the fact that the growth has ulcerated, causing disappearance of the stenosis, and it will then be found that a large tube can be easily passed into the stomach. Similarly, in cases of carcinoma of the pylorus accompanied by obstinate vomiting, the intervals may become longer and longer, until the vomiting altogether ceases, owing to the softening and sloughing of the tumour.

The appearance of the vomited matter varies according to the food taken ; in all cases, however, it shows a marked want of efficient motility and of breaking up of the food, even in spite of peristaltic waves being noted on examination of the abdominal wall ; and remnants of food from previous days are generally present. Bile is practically never found in malignant disease of the stomach, but there are often large quantities of mucus, intimately mixed with the stomach contents. In nearly all cases, blood in small quantities will, sooner or later, be found in the vomit. But the blood in carcinoma, as distinguished from that found in ulceration, is small in amount, since it comes from small superficial abrasions, and to demonstrate its presence it is often necessary to resort to chemical tests. In rare cases, owing to the breaking-down of the growth, there may be erosions of large vessels leading to copious hæmorrhage which may be difficult to distinguish from those of gastric ulcer.

Chemical Examination of the Vomited Matter in Carcinoma of the Stomach.—In a case of carcinoma of the stomach verified by autopsy, Golding Bird,[1] of Guy's Hospital, first showed in 1842 that the free hydrochloric acid,

[1] "Contribution to Chemical Pathology of some Forms of Morbid Digestion," *Lond. Med. Gaz.*, 1842, vol. ii. p. 391.

which was present in considerable quantities in the early stages of the disease, gradually diminished in amount as the strength of the patient decreased, and that the organic acids gradually increased as the free hydrochloric acid diminished.

Van den Velden[1] in 1879 again drew attention to the fact that in carcinoma of the pylorus, free hydrochloric acid was absent from the stomach contents. Since this period, a number of writers both for and against the absence of free hydrochloric acid have taken the field. The discrepancies in the opinions of the various writers are partly due to their not recognising the difference between free and combined hydrochloric acid. The diminished secretion of hydrochloric acid and the absence of free hydrochloric acid are not, however, pathognomonic of carcinoma; it was long ago shown by Van den Velden that both in gastritis and fever, one may find absence of free hydrochloric acid. Riegel[2] has further shown that in amyloid disease of the mucous membrane of the stomach, toxic gastritis, atrophic catarrh, and certain forms of nervous disease—and sometimes even in phthisis and heart disease—free hydrochloric acid is absent from the stomach contents. In most cases, the other signs and symptoms help one to diagnose whether its absence is due to malignant disease or other causes, and it must be remembered that one would rarely venture to diagnose carcinoma of the stomach from an analysis of gastric contents alone.

The question of how soon in carcinoma of the stomach hydrochloric acid disappears is a very difficult one to settle; it certainly seems that, as the disease advances, the quantity of hydrochloric acid diminishes, and in some cases free hydrochloric acid is entirely absent at a very early stage when no other signs or symptoms of carcinoma are present. On the other hand, there are certain cases of carcinoma in which one finds free hydrochloric acid to be present for a long time, and further one even occasionally gets hyperhydrochloria. Those cases in which hydrochloric acid remains present throughout—even, it may be, in increased quantity—are usually associated with ulceration, partaking of a carcinomatous nature.

Thiersch[3] described a very interesting case in which free hydrochloric acid was present, and at the autopsy, cancer was found

[1] *Loc. cit*, p. 25. [2] *Die Erkrankungen des Magens*, 1897, p. 788.
[3] *Münchener Med. Wochenschrift*, 1886.

to be growing on the site of an old gastric ulcer. We can say with confidence that, when the signs and symptoms point to malignant disease, the absence of free hydrochloric acid from the vomit is a very great factor in confirming the diagnosis of carcinoma, and, unless there is some evidence to lead one to suspect the presence of gastric ulcer, the presence of free hydrochloric acid in such cases would negative such a diagnosis.

Microscopic Appearance of the Vomited Matter in Carcinoma of the Stomach.—In examining the sediment obtained from the vomit or washings of the stomach in malignant disease of that organ, it is not at all uncommon to find epithelial cells, sometimes arranged in the characteristic nests found in carcinoma. Reinboth[1] describes how in small blood clots obtained from the washing out of a malignant stomach, small particles of the growth are sometimes found. Unfortunately, the microscopic recognition of carcinoma is not, in most cases, possible till the later stages of the disease, and the diagnosis may be made earlier by other means.

In the vomited matter of carcinoma of the stomach, one generally finds remains of muscular fibres, vegetable cells, starch granules, and fat globules, which are easily recognised. Sarcinæ are usually absent, and Oppler[2] has shown that if one introduces pure cultures of sarcinæ into a carcinomatous stomach, they disappear within twenty-four hours, a dilated malignant stomach being a very bad nourishing chamber for these organisms; this is contrary to what occurs in ordinary atonic dilatation of the stomach. It is not at all uncommon to find yeast cells in the stagnated contents of a carcinomatous stomach. In almost all cases of carcinoma, one finds long filamentous bacilli which are productive of lactic acid.

Boas[3] has observed more or less large quantities of pus cells in malignant disease of the stomach, but Riegel[4] considers that these are more often due to accidental contamination than to the malignant disease itself.

Chemical Examination of the Gastric Contents after a Test Breakfast.—The appearance of the gastric

1 *Deutsch. Archiv. f. Klin. Med.*, Bd. lviii. 89.
2 *München. Med. Wochenschr.*, 1894, No. 29.
3 *Diagnostik u. Therap. der Magenkrankheiten II.*, Theil, 1896, p. 184.
4 *Die Erkrankungen des Magens*, 1897, p. 788.

contents obtained after one hour in malignant disease varies very considerably according to the position of the growth. When the disease occurs towards the pylorus, leading to obstruction, one has the complication of a more or less dilated stomach, which does not occur when the growth is at the cardiac end. Unless special precautions are taken in cases where the malignant disease is in the pylorus and dilatation is present, it is not uncommon to find mixed with the tea and toast some remains of the previous day's food. And if one

TABLE VII.—ANALYSIS OF GASTRIC CONTENTS IN GASTRIC CARCINOMA

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).			Remarks.
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3	
B. 10	acid	0	+	0	+ +	—	—	—	—	—	—	0	0	0	Cardiac
C. 67	acid	0	+	+	+	17	—	0·13	0·00	0·02	0·11	0	0	0	Cardiac
G. 13	acid	0	+	+	0	40	15	0·22	—	—	—	0	25	0	Pyloric
J. 85	acid	0	+	+	+	47	22·4	0·32	0·00	0·16	0·16	0	0	0	Pyloric

(*a*) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(*b*) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

wishes to obtain a proper gastric analysis in such cases, it is necessary to wash out the stomach on the evening or morning before the test breakfast is given.

The quantity of gastric contents varies considerably according to the situation of the carcinoma. In early cases of malignant disease at the cardiac end while the tube can still be passed, there is a tendency to decrease in the quantity of gastric contents, which is apparently due, not so much to increased motor-power, as to the difficulty of removing the contents, for, on washing out with water, one continues to obtain contents for some time, showing marked difficulty in thoroughly cleaning the stomach. Scarcity of pure material often hampers analysis.

In the above table we give four cases of malignant disease of the stomach, which, soon after analysis, were verified by autopsy. In the first two cases, the carcinoma was either at the greater curvature or towards the cardiac end. In the two latter, there was malignant disease involving the pyloric orifice.

The gastric contents in all the cases showed large particles of toast which had been little broken up, mixed with a certain amount of mucus in three of the cases. In no case was any blood found.

The reaction was in all these cases distinctly acid, and it would appear rare to obtain a neutral reaction in carcinoma. In these four cases, the various tests for free hydrochloric acid were negative. In describing the vomited matter in cancer of the stomach, we have remarked how sometimes free hydrochloric acid may be present, and the repetition of these remarks is unnecessary.

In all cases, the test for lactic acid gave a marked reaction. We have already mentioned the fact that long filamentous bacilli which produce lactic acid are considered by Boas to be always present in malignant disease. It would appear that in carcinoma there is a greatly increased quantity of lactic acid after a test breakfast, and that even when Boas's oatmeal soup has been given, lactic acid will be found. Its presence is a very early symptom in carcinoma, and is, therefore, of great diagnostic value. At the same time, Hammerschlag[1] has shown that it is not uncommon to find lactic acid only slightly increased in those cases of malignant disease where the proteid digestion is normal, or only very slightly reduced.

One finds butyric acid present in most cases of carcinoma. Even when there is no obstruction to the pylorus, there appears to be a tendency to stagnation of the contents in the stomach, so that butyric acid occurs in the early stages of malignant disease. Of the four cases given above, butyric acid was easily recognised in all except one; in this case, there was a suspicion of its presence, though the quantity of material was not sufficient to allow of a very detailed analysis.

Mucus is, as a rule, present in carcinoma, this being due to the fact that a certain amount of catarrh generally accompanies the disease. Undoubtedly there are cases of malignant disease

1 *Archiv. f. Verdauungskrankheiten*, vol. ii. part i.

in which mucus is not increased, and in one of the cases described above it was absent.

The total acidity in carcinoma is, as a rule, decreased, as is well illustrated in the examples taken. In rare cases, where the carcinoma has followed upon gastric ulcer, one may find, as has been described, no decrease in total acidity.

In all cases of carcinoma in which we have been able to do a quantitative analysis of the volatile acids, we have found them increased. Of the four cases which were verified by autopsy, there were sufficient gastric contents in only two to allow of an estimation of the volatile acids, and in these two cases, they amounted to 15 and 22·4 respectively.

The total quantity of hydrochloric acid in most cases of carcinoma of the stomach is decreased. In one of the cases given above, the total hydrochloric acid was 0·32 per cent., but in this case the analysis was done some months before the autopsy, at which a tumour was found extending towards the pyloric orifice ; in the other cases it is seen that the total hydrochloric acid is decreased.

In all uncomplicated cases, free hydrochloric acid is absent ; one has to remember, however, the cases where gastric ulcer precedes the malignant disease, when this will not be the case.

In the majority of cases, it would appear that the combined hydrochloric acid is decreased, and in some cases entirely absent. We see in the table that in the one case in which the total quantity of hydrochloric acid was apparently normal, no less than 0·16 per cent. was combined with the proteids.

The mineral hydrochloric acid is, as a rule, very large in amount. In the two cases in which analyses were carried out it was 0·11 and 0·16 per cent., resembling what one finds in acute gastric catarrh.

The carmine fibrin test shows for the most part absence of digestion. The diminution of pepsin is not pathognomonic of the disease, since in all cases of secondary gastritis or atrophy of the stomach there is a tendency to diminution of pepsin and pepsinogen, as well as of other ferments. In malignant disease of the stomach, one finds both pepsin and rennin as a rule diminished, and it is not at all uncommon to find both these ferments entirely absent. In three of the four cases given in the table, this was the case. In only one case was there a slight digestion after twenty-five minutes in test-tube No. 2 to which four per mille hydrochloric acid had been added.

We see that the chemical analysis of the gastric contents after a test breakfast in cases of malignant disease of the stomach yields very valuable results in helping to make a diagnosis. At the same time, it must be remembered that the symptoms and general examination of the patient should in all cases be very carefully weighed together with the analytical results before any definite conclusions can be drawn.

CHAPTER XI

FUNCTIONAL DISEASES OF THE STOMACH—SECRETORY NEUROSES, HYPERHYDROCHLORIA, GASTRO-SUCCHOREA, HYPOHYDROCHLORIA

In functional dyspepsia one is now able, thanks to the introduction into general practice of the stomach-tube, to recognise the changes produced in the gastric secretion, as well as the changes in the condition of the stomach wall itself, so that one can classify the pathological state with a certain amount of scientific accuracy.

The majority of cases of chronic gastric dyspepsia which come under the notice of medical men will, when careful chemical examination of the stomach contents has been made, prove to be due to functional disturbance and not to organic disease. Functional disturbance of the stomach may, for the sake of convenience, be divided into three groups, due to alterations in :

(*a*) The secretions of the stomach.
(*b*) The motor-power of the stomach.
(*c*) The sensibility of the stomach.

It will be found in all cases of functional disease of the stomach that the more often one is able to obtain an analysis after a test meal, the more accurate will be the diagnosis ; in looking through our notes of gastric analyses the importance of having a series of analyses is very apparent. In all cases where this has been possible, there has not been the slightest difficulty in classifying the condition of the stomach, while in those cases where only a few, or possibly only one analysis has been made, one may easily be led into error in diagnosis, especially when the results of chemical analysis are not very typical of the condition present.

It is important also, in diagnosis by means of chemical analysis, not to diagnose functional disease of the stomach until organic disease has been negatived by a very careful examination of the symptoms and physical signs present. Functional dyspeptics, as a rule, show other nervous symptoms, such as neurasthenia, &c., which help one in making a diagnosis, but on this account, the error must not be made of overlooking possible organic disease in a neurotic patient.

Functional dyspepsia is especially prevalent in the upper and middle classes who are in the habit of cultivating their brains more than their bodies, and one finds many instances of it in the legal and medical professions, and in over-worked business and literary men, &c. The condition is found most frequently in persons of active middle life, rather than in the young or old, and secretory dyspepsia would appear to be more common in men than in women, while motor derangement of the stomach is more frequently met with in women than in men. One would naturally expect that a single function of the stomach would seldom be alone at fault, and in practice it is not at all uncommon to have two or three functions disturbed at the same time in the same individual, so that hyperhydrochloria, together with hyperæsthesia and atonic dilatation of the stomach, may be present in the same patient.

When the motor-power of the stomach is interfered with, one gets various groups of symptoms, according to the part of the stomach especially affected; in some cases, pyloric spasms seem to be the principal symptom, in others increased peristalsis, and in others again, loss of tone may give rise to atonic dilatation.

With these prefatory remarks, we may now go on to subdivide the various forms of functional dyspepsia met with in practice, and illustrate them with analyses of cases. The analysis given in each table is a single one chosen from a series of analyses of a separate case, as illustrating the condition generally found; by this means one gets a better picture of the condition present in that particular disease.

As an example, we will take one case of hyperhydrochloria in which a series of analyses was carried out. It will be seen in this case (Table VIII.) that the various analyses correspond in general and enable one to recognise the case as one of purely functional disease. On two occasions mucus was present, and the volatile acids were sometimes increased; these analyses alone might lead one to believe that there was some gastric catarrh, but on looking at the analyses as a whole, one sees that no catarrh was present, and that it was a case of hyperhydrochloria, the increased volatile acids being due to temporary motor insufficiency. The lactic acid which is shown to be present in all the analyses was only found in very small quantities, and is due to a test breakfast only being employed, and not Boas's oatmeal soup.

TABLE VIII.—ANALYSIS OF GASTRIC CONTENTS IN A CASE OF HYPERHYDROCHLORIA

Date.	Qualitative.					Quantitative.						Digestion in minutes (b).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3
7·11·98	acid	+	+	0	0	93	5·2	0·365	0·058	0·215	0·091	10	11	17
14·11·98	acid	+	+	+	0	92	6·5	0·37	0·05	0·21	0·10	6	11	17
14·12·98	acid	+	+	+	0	84	12·4	0·365	0·069	0·181	0·115	6	9	14
29·12·98	acid	+	+	+	+	85	12·8	0·336	0·033	0·186	0·117	9	8	15
11·1·99	acid	+	+	0	0	74	6·4	0·354	0·069	0·183	0·102	6	8	16
20·1·99	acid	+	+	+	0	81	8·0	0·376	0·022	0·245	0·109	5	7	11
26·1·99	acid	+	+	+	0	88	14·0	0·398	0·073	0·215	0·110	5	5	11
30·1·99	acid	+	+	0	0	81	5·2	0·39	0·02	0·25	0·12	5	7	12
3·2·99	acid	+	+	+	+	90	12·8	0·38	0·04	0·23	0·11	7	8	14

(a) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(b) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " " of water.

SECRETORY NEUROSIS OF THE STOMACH

That the secretions of the stomach are under the control of the nervous system has long been believed, and naturally so, since other secretory glands have been demonstrated to be under the control of the nerves. Numerous observers have tried to show how the nervous secretions of the stomach are influenced by stimulation or inhibition, but no experiments on either the vagus or sympathetic seemed to give any definite and constant results in animals.

It was not until Pawlow and his pupils, with their more refined methods of experimenting and their careful use of antiseptics, showed that gastric secretion was under the control of the vagus, that our knowledge from the experimental side was established. In dogs in which he had made œsophageal and gastric fistulæ, he was able to prove that the mere psychological stimulus of seeing food, &c., sufficed to cause secretion of the stomach juice. That the gastric juice really came from the psychological stimulus, he demonstrated by his ingenious method of dividing the stomach into two parts, so that he had a small stomach isolated from the œsophagus with a gastric fistula in it. By feeding these dogs—when there was no possibility of food entering the stomach from the œsophagus—he was able to collect absolutely pure gastric juice from the small isolated stomach. Section of the vagi with certain precautions caused complete absence of any psychological secretion in dogs thus fed, and still further, stimulation of the peripheral end of the vagus produced a distinct flow of gastric juice. Pawlow[1] was thus able to demonstrate that the secretory nerve of the stomach was the vagus, and that it probably contained not only stimulating, but also inhibitory fibres.

All Pawlow's work is so interesting and so experimentally conclusive, that we must refer our readers to the book itself, since it is of great importance in enabling us to understand how functional changes produced in the stomach may account for dyspepsia.

Richet[2] had under observation a patient with obstructed œsophagus and gastric fistula in whom, after chewing flavoured food—although none of it reached the stomach—he found a copious flow of gastric juice, just as has been now demonstrated in animals by Pawlow.

Having seen that the gastric secretion is so easily influenced by psychological stimulation, we can readily understand how in disease either stimulation or inhibition of the vagus may act on the gastric glands so as to affect the secretions. The chemical reflex caused by gastric secretion may be found to play an important *rôle* in the pathological alterations of the composition of the gastric juice, but the subject is too recent to be discussed here.[3] In cases of stimulation of the vagus,

1 *Loc. cit.* p. 10.

2 *Journ. de l'Anatom. et de la Physiol.*, iii. No. 6.

3 *Starling, Croonian Lectures*, June 1905.

one would expect increased gastric secretion, leading to hyperhydrochloria when food is taken, or, when such stimulation occurs in the fasting individual, gastro-succhorea. While, on the other hand, in cases where inhibition of the vagus occurs, one may get hypohydrochloria.

Pathologically, hypersecretion of the gastric juice may occur

TABLE IX.—ANALYSIS OF GASTRIC CONTENTS IN HYPERHYDROCHLORIA

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3
P. 6	acid	+	+	+	0	92	6	0·37	0·05	0·21	0·10	6	11	17
P. 10	acid	+ +	+	0	0	108	4	0·41	0·06	0·28	0·07	8	5	5
T. 12	acid	+	+	+	0	106	8	0·42	0·02	0·29	0·10	13	9	15
C. 17	acid	+	+	0	0	75	3	0·34	0·01	0·23	0·10	10	5	5
S. 23	acid	+	+	+	0	116	9	0·36	0·02	0·26	0·08	4	4	6
C. 32	acid	+	+	+	0	102	6	0·40	0·03	0·30	0·07	2	6	3
C. 51	acid	+	+	+	0	125	9	0·48	0·02	0·29	0·17	2	3	5
P. 63	acid	+	+	+	+	100	4	0·36	0·01	0·28	0·07	5	4	6
L. 76	acid	+	+	+	+	94	9	0·37	0·01	0·30	0·06	2	2	3

(a) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(b) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

in two forms, that present during digestion, which is recognised as hyperhydrochloria, and that from a fasting stomach, which is known as gastro-succhorea.

HYPERHYDROCHLORIA

The condition of hyperhydrochloria is best defined as an excessive secretion of gastric juice occurring during digestion, either the gastric secreting cells or the secretory fibres of the vagus being more sensitive than is normal, so that the excitation of the food causes an excessive secretion of juice. The analysis of such gastric contents will show not only increased total acidity, but also an increase in both free and combined hydrochloric acid. In this condition the ferments, pepsin and rennin, are usually increased, as well as the acids normally present in the gastric juice.

In all cases of functional disease of the stomach, it is important, as already stated, to have a series of analyses ; in this way one obtains more definite results than is possible when one attempts to make a diagnosis from a single analysis. In Table IX. we have put together the results of nine analyses of different individuals as types of the various forms of hyperhydrochloria which one meets with in everyday practice.

The quantity of gastric contents found after a test breakfast is, as a rule, somewhat increased in cases of hyperhydrochloria ; at the same time, this is not always demonstrated, owing to the fact that the condition is often accompanied by increased motility, so that one does not obtain such a large quantity of gastric contents after the hour's interval as one would expect to find where there is excessive secretion of gastric juice.

Qualitative Analysis.—A markedly acid reaction is present in all cases of hyperhydrochloria.

One would naturally expect to find a very marked reaction with the various tests for free hydrochloric acid in cases where there is a hypersecretion of gastric juice, and in cases of hyperhydrochloria, one will find that the reaction for hydrochloric acid is always very distinct.

When the ordinary test breakfast has been given, one generally obtains a slight colour reaction with the test for lactic acid, but when Boas's oatmeal porridge has been given as a test diet, the test for lactic acid will be negative.

Butyric acid is often found in hyperhydrochloria ; the condition is accompanied by some diminution in the motor-power of the stomach, the butyric acid being due to this delayed motility.

In uncomplicated cases, mucus is not, as a rule, present, although in some cases we have found it in a single analysis ; when, however, several analyses have been carried out, we have found that the presence of mucus was not constant, and was apparently accidental. One sees, on comparing a series of analyses of the same individual, that mucus is, as a rule, absent in cases of hyperhydrochloria, while in cases of catarrh of the stomach, it is always present. It would appear that in simple hyperhydrochloria, mucus is not so often present as it is in cases complicated with gastric ulcer.

Quantitative Analysis.—The total quantity of acid present in hyperhydrochloria varies from 60 to 130, or even more. In the series of cases which we have given as types, it varies from 75 to 125. In most cases of uncomplicated hyperhydrochloria the acidity will be about 100, and it should be considered that any increase above 60 of acidity verges on hyperhydrochloria. The line of demarcation between normal gastric secretion and the slight excess which occurs in mild cases of hyperhydrochloria is difficult to define, as the symptoms may be very marked in some cases where the acidity is only slightly increased, owing to hyperæsthesia being also present. Conclusions as to the class of functional diseases of the stomach in which such cases are to be placed can only be made by a series of analyses.

In hyperhydrochloria, the volatile acidity will be found to be normal, while there is a tendency in some cases for it to be increased. In three of the cases it was increased to as much as 9. This increase in the volatile acidity will generally be found to be due to diminished motility accompanying the condition.

Quantitative Analysis of Hydrochloric Acid.—The total hydrochloric acid is always increased. In the series of analyses given, the lowest figure is 0·34 per cent., and the highest 0·48 per cent., the analyses generally tending towards the higher figure rather than the lower.

Free hydrochloric acid, as already stated, is always found by chemical tests to be present. The quantitative analysis varies in the cases given from 0·01 to 0·06 per cent., though higher figures may occasionally be reached.

The quantity of hydrochloric acid combined with proteids will always be found to be increased, varying from 0·21 to 0·30 per cent. in the examples quoted.

The quantity of chlorine combined with the minerals in hyperhydrochloria varies, but the general tendency is for the quantity not to be markedly increased. In the examples given, it varies from 0·06 to 0·10 per cent.

Digestion. — In hyperhydrochloria, one finds, with the carmine fibrin test, rapid digestion, so that in some cases the fibrin is dissolved and the carmine liberated in as short a time as two minutes. The addition of hydrochloric acid to the gastric contents in test-tube No. 2 may, in some cases, tend to delay digestion owing to the excess of hydrochloric acid hindering the action of the pepsin. The general conclusion to be deduced from the examination of several cases of hyperhydrochloria is that pepsin and pepsinogen are present in normal or even increased quantities.

The examination for rennin, when the gastric secretion has been previously neutralised, will also show a tendency to increased activity.

The chemical analysis in cases of hyperhydrochloria is seen to correspond with that of gastric ulcer, and this is not remarkable when one considers that in gastric ulcer one has a condition of hypersecretion. The differential diagnosis between gastric ulcer and hyperhydrochloria is therefore extremely difficult, and can only be arrived at by considering the symptoms and clinical history. In cases where one gets an undoubted history of hæmatemesis, the diagnosis is comparatively easy, but in other cases one must rely on the general history and symptoms, and it would appear that the stomach-tube is of very little aid in coming to definite conclusions.

GASTRO-SUCCHOREA

In healthy individuals, a resting stomach contains no gastric secretion, so that on passing the stomach-tube in a fasting individual, no gastric contents should be obtained. It is important before making a diagnosis of gastro-succhorea, when one finds gastric contents in a fasting individual, to wash out the stomach the previous night in order to be sure that the gastric contents are not due to the excitation of remnants of food or secretion which has irritated or stimulated the stomach. If, having previously washed out the stomach, one still finds gastric contents on passing the stomach-tube, one may safely consider that the patient is suffering from gastro-succhorea.

The frequency of this condition would appear to vary considerably according to different observers, and the countries in which the observations have been made. It appears to be quite common in Norway amongst badly fed individuals, and Dr. Grieg, of Bergen, who worked in our laboratory, was good enough to send us a series of analyses of patients suffering from gastro-succhorea. The analyses simply show normal gastric juice, and it is unnecessary to reproduce them here. Not only is hydrochloric acid present in such cases, but also pepsin and generally rennin.

HYPOHYDROCHLORIA

We have already shown that hyperhydrochloria is due to excitation of the secretory fibres of the vagus nerve, the con-

TABLE X.—ANALYSIS OF GASTRIC CONTENTS IN HYPOHYDROCHLORIA

Case.	Qualitative.					Quantitative.						Digestion in minutes (*b*).		
								HCl.						
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (*a*).	Volatile acid (*a*).	Total.	Free.	Proteid.	Mineral.	1	2	3
E. 11	acid	0	+	+	+	30	10	0·26	0·00	0·13	0·12	0	0	0
P. 53	acid	0	+	+	0	30	8	0·09	0·00	0·01	0·07	0	15	0
C. 55	acid	0	+	+	+	24	7	0·16	0·00	0·02	0·14	0	2	0
J. 62	acid	0	+	+	0	40	7	0·25	0·00	0·07	0·18	0	5	0
C. 78	acid	0	+	+	0	22	4	0·13	0·00	0·05	0·08	0	30	0
U. 79	acid	0	+	+	+ +	20	11	0·26	0·00	0·06	0·20	0	22	0
P. 102	faint acid	0	0	0	0	18	9	0·16	0·00	0·04	0·12	0	0	0

(*a*) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(*b*) 1. Filtered Gastric contents and carmine fibrin.
2. ,, ,, ,, ,, and equal quantity 0·4 p.c. HCl.
3. ,, ,, ,, ,, ,, ,, of water.

trary condition—diminished secretion of gastric juice or hypohydrochloria—being produced by the excessive action of the inhibitory fibres of the vagus nerve. The diminished secretion which occurs in gastric catarrh or in carcinoma of the stomach must at once be separated from this purely neurotic condition of hypohydrochloria. In the former cases, there is often absolute destruction of the gastric juice secreting glandular cells of the mucous membrane, while functional hypohydrochloria is accompanied by no destruction of the secreting cells, but merely inhibition through the vagus nerve causing diminished secretion. Hypohydrochloria is found in practice to be a much more rare complaint than the opposite condition of hyperhydrochloria. This is only what one would expect on physiological grounds, since the inhibitory function is not so strongly represented in the vagus nerve as the excitatory function.

In Table X. we have put together seven cases illustrative of this condition. It is found that after a test breakfast a large quantity of gastric contents is, as a rule, obtained, showing that delayed motility usually accompanies the condition.

Qualitative Analysis.—The reaction in all cases of hypohydrochloria which have come under our notice has been acid or feebly acid; in no case have we obtained a neutral reaction.

In hypohydrochloria the ordinary tests for the presence of hydrochloric acid occasionally give a reaction, but in more numerous cases, free hydrochloric acid is absent.

Lactic acid has been found to be present in nearly all the cases we have examined after the ordinary test breakfast, but when Boas's oatmeal porridge has been given, it is very often absent, and never found in any increased quantity. This is of considerable help in distinguishing this condition from that of malignant disease of the stomach, in which one finds the excessive quantity of lactic acid already mentioned.

In the majority of cases, butyric acid will be found to be present, though in some few cases it is absent.

In typical hypohydrochloria, mucus is absent, though in taking a series of analyses—as in hyperhydrochloria—one may occasionally find it present. The importance of a series of analyses in these cases in helping one to distinguish the condition from carcinoma of the stomach is very apparent, for, in carcinoma of the stomach, the majority of analyses will reveal the presence of mucus, whereas in hypohydrochloria, it will be absent.

Quantitative Analysis.—In hypohydrochloria the total acidity is found to vary from 18 to 40 in the cases we have taken as types, and some show an even smaller acidity.

In uncomplicated hypohydrochloria one would expect the volatile acidity to be normal. In the cases which we have taken as examples, it has occasionally been almost normal, but in the majority of cases it tends to be increased, from 8 to 11. This is partly due to delayed motility causing the stagnant gastric contents to ferment, the inhibitory action of the hydrochloric acid being no longer sufficient to stop the action of bacteria. This is what one would naturally expect, if the views of Bunge and others, who hold that hydrochloric acid acts merely as an inhibitor of bacterial action, are correct. In no case of hypohydrochloria where there has not been delayed motility, have we been able to find any morbid increase in the volatile acidity.

Quantitative Analysis of Hydrochloric Acid.—The total hydrochloric acid in cases of hypohydrochloria varies in the cases we have given from 0·26 to 0·09 per cent. The majority of cases, however, vary from 0·12 to 0·19 per cent.

In some cases, a trace of free hydrochloric acid may be present, although, as a rule, one finds total absence of this substance.

The quantity of chlorine combined with the proteids is always low, the quantity varying from 0·01 to 0·13 per cent. Unlike what one finds in organic disease of the stomach, we have never come across a case of hypohydrochloria of purely neurotic origin where proteid chlorine was entirely absent.

The chlorine combined with minerals varies very much. In some cases the quantity is low—0·07 per cent.—while in others it is increased, and may reach as much as 0·20 per cent.

Digestion.—In hypohydrochloria there is a tendency for the digestion to be distinctly delayed, so that no digestion occurs until one has added a four per mille solution of hydrochloric acid to convert the pro-pepsin present into active pepsin. But in some cases digestion does occur even without the addition of hydrochloric acid. It would appear from digestion experiments that the ferments are rarely absent, and that the delayed digestion is due to the diminished quantity of hydrochloric acid; at the same time, we have seen undoubted cases of functional hypohydrochloria in which pepsin and pepsinogen were entirely absent, in some of these cases rennin also having been absent.

CHAPTER XII

FUNCTIONAL DISEASES OF THE STOMACH (*continued*)—MOTOR NEUROSES, HYPERMOTILITY AND HYPOMOTILITY

THE motility of the stomach being under the control of the nervous system, both as regards its activity and muscular tone, this function can be altered in two directions :

(*a*) Hypermotility, or increased functional activity, which may affect the whole organ and sometimes causes a condition of peristaltic restlessness, or may excite rumination. The increased motility may be limited to different parts of the stomach, such as the pyloric or cardiac region, leading to muscular spasm.

(*b*) Hypomotility, which includes the loss of both motor-power and tone through deficient nerve impulses. The former, when affecting the body wall of the stomach, produces atonic dilatation of that organ ; the latter, if the insufficiency is limited to the cardiac end, may cause regurgitation of food, or if the pyloric region is affected, leads to pyloric insufficiency.

(*a*) **Hypermotility.**—General hypermotility of the stomach may in some individuals be habitual, so that the food taken is more rapidly passed on into the duodenum than occurs in a healthy individual. In one case which we had under observation—that of a surgeon-major in the Indian army—we found that after a test breakfast the stomach was always empty within twenty minutes ; on washing out the stomach after this interval no remains of toast, &c., could be obtained. A meat meal was also found to leave the stomach very rapidly, so that it would be found empty in one hour. Unfortunately, only a few experiments could be carried out in this case, as the patient, being perfectly well, objected to the use of the stomach-tube. As a general rule, we may consider that hypermotility is accompanied by no disagreeable sensations, and in the case in question, the individual did not even feel hungry in consequence of the rapid emptying of the stomach. The diagnosis is easily made by

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passing the stomach-tube at various intervals after a test meal. In a pure case of hypermotility, one will find the stomach contents perfectly normal if the interval after the test meal has been taken is short enough. In many cases, however, one finds other gastric functions disturbed, more especially the secretory functions, leading to—in the majority of cases—hyperhydrochloria.

A condition of the stomach known as peristaltic restlessness, has been described by Kussmaul[1] in which the muscular disturbance of the stomach wall was due to the peristaltic nerve apparatus being upset; in fact, a true motility neurosis. The peristaltic movements, in these cases, occur early in the morning, so that the fasting stomach which only contains air is felt by the patient to be in a state of unrest, and the peristalsis can in some cases be observed by the physician. The condition is increased to a marked extent after taking food. Unfortunately, we have no record of analyses showing the chemical composition of the gastric contents under such circumstances; it would, however, appear that peristaltic restlessness is very often accompanied by gastro-succhorea.

Increased peristalsis, causing sensations of pain in the stomach, may also occur when there is stenosis of the pylorus or duodenum, but this can hardly be considered as purely functional.

Rumination, although partly due to insufficiency of the cardiac sphincter, can probably be included under hypermotility, since in a pure case of rumination the gastric contents are brought up by the muscular contraction of the stomach wall. Sometimes the cardiac sphincter of the stomach remains under the will-power of the patient, who, whenever he pleases, can bring up the food into his mouth. In other cases it appears that the will-power has not sufficient control, and the patient is periodically troubled with rumination. In the analyses of ruminating patients, we have on occasion found the gastric contents to be of normal composition, although it is not uncommon to find the secretions functionally altered, generally tending in the direction of hyperhydrochloria.

Spasm of the cardia may occasionally occur, causing a painful cramp. The condition of cardiac spasm is easily recognised when one attempts to pass the stomach-tube; it will suddenly

1 Volkmann's *Samml. Klin. Vorträge*, No. 181, 1880.

stop in its passage along the œsophagus, and if one attempts to force it, it will tend to turn on itself. While—as distinguished from what would occur in organic disease—if one allows the tube to remain a few minutes above the constriction, the cramp suddenly relaxes, and the tube slips into the stomach.

Spasm of the pylorus causes a distinct cramp in the pyloric region of the stomach which may lead to sensations of faintness. When such spasm lasts for any length of time, one may, after a test breakfast, find an excessive quantity of gastric contents. Spasm of the pylorus is not uncommonly accompanied by hyperhydrochloria, and it is necessary in such cases to be very careful in making a diagnosis so as not to confound them with gastric ulcer, leading to narrowing of the pyloric end of the stomach.

(*b*) **Hypomotility.**—Diminished motility of the stomach may be either a temporary or a more or less permanent condition. One of us, together with Dr. Leney,[1] has already published an account of a patient, who under ordinary circumstances had a normal motor-power with normal gastric secretions, but who, when suffering from migraine with some nausea, evinced marked delay in the motor-power of the stomach.

TABLE XI.—DELAYED MOTILITY DUE TO MIGRAINE

Analysis.	Total HCl.	Free HCl.	Proteid HCl.	Mineral HCl.	Proteid + Free HCl.	Volatile Acidity in c.cm. $\frac{1}{10}$ N. NaOH.
1	0·330	0·010	0·270	0·050	0·280	16·0
2	0·310	0·014	0·235	0·065	0·249	11·0
3	0·335	0·015	0·265	0·050	0·280	8·0
4	0·345	0·042	0·225	0·080	0·267	6·0
Average	0·330	0·020	0·249	0·061	0·269	10·0

The above table illustrates this point by four different analyses.

1 "An Experimental Enquiry into the Quantity of Volatile Acids in the Stomach." L. Leney and Vaughan Harley.—*Brit. Med. Journ.*, May 1899.

The chemical analyses of the gastric contents in this patient showed that, in spite of delayed motility, there was no variation from the normal in the secretion of hydrochloric acid. The volatile acidity, on the other hand, was very markedly increased, the total in four analyses varying from 6 to 16.

Permanent hypomotility, or atonic dilatation of the stomach, is a condition very frequently met with in practice. These are among the cases in which one finds the well-known stomach splash, the patients so often complaining that they feel as if they had a hot-water bottle inside them.

TABLE XII.—ANALYSIS OF GASTRIC CONTENTS IN MOTOR INSUFFICIENCY

Case.	Qualitative.					Quantitative.						Digestion in minutes (*b*).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (*a*).	Volatile acid (*a*).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3
B. 55	acid	+	+	+	0	96	6	0·41	0·03	0·24	0·14	2	1	3
C. 54	acid	+	+	+	+	100	7	0·41	0·03	0·28	0·10	3	2	4
M. 2	acid	0	+	+	0	58	7·2	0·24	0·00	0·12	0·12	8	9	16
M. 59	acid	+	+	+	0	37	9·8	0·18	0·00	0·10	0·08	0	35	0
A. 68	acid	+	+	+	+	98	12	0·34	0·03	0·24	0·08	2	3	5
S. 26	acid	+	+	+	0	60	12·6	0·24	0·01	0·23	0·0	8	7	9
S. 43	acid	+	+	+	0	80	16	0·28	0·02	0·16	0·11	3	5	5
P. 98	acid	+	+	+	+	58	17	0·25	0·00	0·18	0·07	0	11	0
T. 75	acid	+	+	+	0	44	18	0·17	0·00	0·11	0·06	40	12	0
N. 4	acid	+	+	+	+	62	18·8	0·31	0·00	0·17	0·14	25	12	0

(*a*) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(*b*) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

In Table XII. we have given ten cases with their analyses as types of the condition of uncomplicated dilatation of the stomach. In most cases one finds an increased quantity of gastric contents after a test breakfast.

Qualitative Analysis.—The reaction in nearly all cases of true motor insufficiency which we have come across has been distinctly acid; in few cases have we found even a neutral reaction.

Free hydrochloric acid is present in the majority of cases, although a negative reaction is sometimes obtained.

Lactic acid would appear to be increased in most cases, and even when Boas's oatmeal porridge has been given, lactic acid will generally be found, though never in any great quantity, thus helping to distinguish the condition from that of gastric carcinoma.

Butyric acid is seen to be present in all the cases of hypomotility which we have given in the table, and this is due to stagnation of the gastric contents leading to butyric fermentation.

Mucus is sometimes found in cases of atonic dilatation of the stomach, although in the most typical cases it is absent. In the table we see that the latter occurred in six cases out of ten.

Quantitative Analysis.—The total acidity in motor insufficiency varies very considerably, some analyses showing excessive acidity, while in others it is diminished, according to the direction in which the secretory functions are affected. In the cases given, the total acidity varies from 37 to 100.

The volatile acids in cases of atonic dilatation of the stomach appear always to be increased; in some cases the increase is slight (in these it is generally found that hyperhydrochloria is marked), and the excess is never to be compared with what one finds in organic constriction of the pyloric region, leading to dilatation of the stomach. In the cases in the table, the volatile acids are seen to vary from 6 to 18·8.

Quantitative Analysis of Hydrochloric Acid.—The total hydrochloric acid in these cases of atonic dilatation of the stomach varied from 0·17 to 0·41 per cent., so that the same wide range which we found in the total acidity occurs also in the quantity of hydrochloric acid in the gastric contents.

In some cases there is an entire absence of free hydrochloric acid, while in others it may be as high as 0·03 per cent.

The amount of chlorine combined with the proteids varies very much, but in no purely functional case that we have seen has there been an entire absence of hydrochloric acid combined with proteids. In the table, it ranges between 0·10 and 0·28 per cent.

The quantity of chlorine combined with the minerals varies as much as the other chlorides; in the cases given, from 0·06 to 0·14 per cent.

Digestion.—The digestion experiments with carmine fibrin show the same differences as have been found in the substances already mentioned. In only two cases was the ferment in the form of pepsinogen, requiring the addition of hydrochloric acid before it became active. In other cases the digestion is practically normal, while in others again there is a tendency to delay. In no case, however, of atonic dilatation of the stomach have we noted an absence of both pepsin and pepsinogen.

It will thus be seen that the quantitative analysis gives us little assistance in making a diagnosis, except so far as the volatile acids are concerned. The chemical analysis in cases of atonic dilatation of the stomach or motor insufficiency shows that the condition may be accompanied by either hyperhydrochloria or hypohydrochloria. In spite of the chemical analysis not enabling us to make a diagnosis, the use of test meals is invaluable. For by this means, we are able to recognise delayed motility even when a test breakfast only is given, while the recognition is even more simple when a test meal containing meat is given and one finds considerable delay in the passage of food from the stomach.

Insufficiency of the cardiac end of the stomach may lead to regurgitation so that, for no apparent reason, the food suddenly returns into the mouth. The chemical analysis in such cases not uncommonly shows hyperhydrochloria, although one does sometimes find regurgitation where only very slight alterations in the gastric secretions occur. In a group of cases of psychical regurgitation, the gastric contents may be found by chemical analysis to be perfectly normal, the regurgitation being due to some peripheral or central stimulation of the vagus leading to inhibition of the nerves of the cardiac end of the stomach.

Insufficiency of the pylorus is not often perceptible to the patient, and is, therefore, seldom brought to the notice of the doctor. When sodium carbonate and citric acid are given so as to form carbonic acid, or when the stomach is distended with air, one finds that, instead of the stomach being blown out as in a normal manner (so that one can easily map it out by percussion), the gas keeps on passing into the intestine, and no tympanitic area can be obtained. The analysis of the gastric contents in some cases of insufficiency of the pylorus shows nothing abnormal, although, as a rule, the secretory functions of the stomach are altered.

CHAPTER XIII

FUNCTIONAL DISEASES OF THE STOMACH (*continued*)—SENSORY NEUROSES, HYPERÆSTHESIA, GASTRALGIA, ANÆSTHESIA, AND VOMITING NEUROSIS

Hyperæsthesia, or increased sensibility of the stomach, can be divided into hyperæsthesia causing general sensations described by the patient as dyspepsia, and the more exaggerated condition known as gastralgia. Hyperæsthesia ought to include all sensations of indigestion—whether of pain or discomfort—in cases where one does not find sufficient alterations in the stomach or its contents to account for such sensations; since the process of digestion ought to be insensibly carried on.

In Table XIII. we have placed together, under the heading of Gastric Hyperæsthesia, eight cases in which the patient suffered from very severe pain or discomfort at periods varying from one to two hours after food, or in the middle of the night. Examination of the motor-power of the stomach showed no real delay in motility.

The quantity of gastric contents after a test breakfast varies very considerably, and gives no definite information.

Qualitative Analysis.—The reaction in all cases was distinctly acid, and in no case was there even a neutral reaction.

Free hydrochloric acid was absent in two of the cases, the other six giving a distinctly positive reaction.

Lactic acid was present after the ordinary test breakfast, but in no case was there any apparent excess.

Butyric acid was absent in four of the cases, and in those in which it was present there was never a very large quantity.

Mucus was found in two of the cases, but it was not constant.

Quantitative Analysis.—The total acidity in these cases, as would be expected from our definition, was practically normal. In one of the cases it was as much as 77 which would allow of its being classified as hyperhydrochloria;

at the same time, the degree of pain and discomfort in this case was altogether out of proportion to the amount of acidity when we consider that the stomach may have an acidity of 100 without any marked symptoms of dyspepsia, and it is, therefore, as well to include the case in hyperæsthesia, especially as there was no increase in the volatile acids. The rest of the cases show a practically normal acidity.

TABLE XIII.—ANALYSIS OF GASTRIC CONTENTS IN GASTRIC HYPERÆSTHESIA

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).		
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	HCl. Total.	HCl. Free.	HCl. Proteid.	HCl. Mineral.	1	2	3
M. 2	acid	0	+	+	0	52	5	0·28	0·00	0·17	0·11	0	8	0
S. 9	acid	+	+	+	0	63	4	0·30	0·02	0·15	0·12	10	8	18
B. 27	acid	+	+	0	+	77	2	0·20	0·01	0·15	0·04	5	4	5
J. 39	acid	+	+	+	0	58	5	0·29	0·02	0·17	0·10	4	4	7
S. 48	acid	0	+	+	+	50	4	0·20	0·00	0·13	0·07	20	8	0
N. 50	acid	+	+	0	0	49	4	0·28	0·04	0·12	0·12	6	4	8
M. 61	acid	+	+	0	0	66	3	0·27	0·02	0·21	0·04	2	3	2
B. 64	acid	+	+	0	0	56	2	0·25	0·01	0·18	0·06	15	4	25

(a) Expressed in c.c. of $\frac{1}{10}$ N. solution of NaOH.
(b) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

The volatile acids are seen to be not much increased, only in two cases amounting to 5. We have often noted that an increase of butyric acid or of the volatile acids causes an excessive degree of pain, and if the pain in these cases was caused by ever so small an amount of acidity, one sees that a sensation of pain is very easily set up in a hyper-sensitive stomach by this irritant.

Quantitative Analysis of Hydrochloric Acid.—The total hydrochloric acid can be regarded as normal in all the cases, free hydrochloric acid being present in all but two of them.

The quantity of hydrochloric acid combined with proteids was, in all cases, what one would expect to find in normal gastric contents, and shows nothing of interest.

The chlorine combined with the minerals was what one finds in stomach analyses where there is not much the matter.

Digestion.—The experiments with carmine fibrin showed that in all but one case pepsin was present, and even in this case, digestion occurred in eight minutes with the addition of four per mille hydrochloric acid, showing that pepsinogen was present. In all probability, rennin is also present in the majority of cases.

It would appear from the consideration of these analyses that when the motor-power of the stomach is found to be normal, one must recognise that, under certain circumstances, a condition of hyperæsthesia may exist. The fact that the analysis is negative makes it all the more valuable, as it precludes the possibility of any gastric disease accounting for the symptoms of indigestion. The testimony of a normal gastric juice secretion justifies one in considering the case to be one of gastric hyperæsthesia of the mucous membrane, and treating it as an entirely neurotic condition. Still further, seeing that the digestion is really normal in these cases where the patients complained of indigestion, it is best in the matter of diet not necessarily to order that which is the most easily digested and assimilated, but rather to give a generous diet, and ensure the patient's taking a proper amount of nourishment, thus educating the nervous system to stand a stimulating and normal diet.

GASTRALGIA

Cases where one gets acute pain, sometimes described as agony, and almost resembling that which occurs in gastric ulcer, may be diagnosed as gastralgia. In such cases, it must be remembered that unless one finds the gastric contents normal in a series of analyses, one is not justified in calling it gastralgia. Where hyperhydrochloria accompanies the condition, one will be prepared to diagnose it as a case of gastric ulcer, while in cases where hypohydrochloria is found, one might be led to diagnose carcinoma of the stomach. So that, in gastralgia as in hyperæsthesia, the chemical analyses, although they give normal results, are of great value in helping to make a diagnosis.

GASTRIC ANÆSTHESIA

The condition of diminished sensibility of the stomach is difficult to recognise in cases where the gastric contents are found to be normal, since, in the normal stomach, digestion is carried on so peacefully that no inconvenience is attached to it, and no sensations of either pain or discomfort are experienced after the taking of food. This being the case, we can see that the healthy individual has a non-sensitive stomach. On the other hand, chemical analysis will show that there are cases in which this non-sensibility of the stomach is carried to extremes. In the examination of healthy individuals, such as students in the laboratory, &c., it is not at all uncommon to find that after the taking of a test meal, the stomach contents are anything but normal, although the patient has suffered from no symptoms of indigestion, and is rather indignant at being told that his stomach is not secreting normal gastric juice. We have come across several cases where hyperhydrochloria existed to a considerable extent in an individual suffering from no gastric symptoms whatsoever. In Table XIV. we give one case of gastric anæsthesia to illustrate this condition.

TABLE XIV.—ANALYSIS OF GASTRIC CONTENTS IN GASTRIC ANÆSTHESIA

Case.	Qualitative.					Quantitative.						Digestion in minutes (b).		
								HCl.						
	Reaction.	HCl.	Lactic acid.	Butyric acid.	Mucus.	Total acid (a).	Volatile acid (a).	Total.	Free.	Proteid.	Mineral.	1	2	3
B. 52	acid	+	+	0	0	118	6	0·47	0·04	0·27	0·11	3	4	6

(a) Expressed in c.c. of $\frac{1}{10}$ N. solution of Na OH.
(b) 1. Filtered Gastric contents and carmine fibrin.
2. " " " " and equal quantity 0·4 p.c. HCl.
3. " " " " " " of water.

In a healthy doctor, aged thirty, the analysis of the gastric contents after a test breakfast showed a condition of hyper-hydrochloria with slightly increased volatile acids. On looking at the table, one sees that otherwise the digestion was carried on well, and in spite of this hyperhydrochloria, the patient suffered from no symptoms of indigestion whatsoever. When one remembers that hyperhydrochloria with a total acidity of about 100 will sometimes cause considerable symptoms of acid dyspepsia, one must recognise that, in addition to a condition of hyperæsthesia, which has already been illustrated, there is also a condition of gastric analgesia.

VOMITING NEUROSIS

A full description of neurotic vomiting need not be given here, but a few words must be said with regard to the vomiting due to nervous causes, as it is of great importance in making a diagnosis to recognise that such cases are due to nervous influences, and are not true dyspepsia. Cerebral vomiting, due to some lesion in the brain, is not at all uncommon, and at the commencement of a case of cerebral vomiting, one finds that the gastric contents contain a considerable quantity of butyric acid, due to delayed motility. When the vomiting has been frequent, the later vomits no longer contain butyric acid, and may consist simply of bile-stained fluid, containing a little mucus. In cases where one has been able to give a test breakfast, one finds the gastric analysis to differ very little from what one expects to find in health. In spinal lesions, the same is found, and the gastric crisis of tabes dorsalis is also illustrative of this condition. In neurasthenia it is not at all uncommon for neurotic vomiting to occur periodically, while in hysteria, one gets hysterical vomiting. In these cases, which are apparently due to irritation of the vomiting centre, the chemical analysis of the vomit is not sufficiently pathological to account for the condition, and the diagnosis must be made by careful investigation of the symptoms and other signs of the disease, a detailed analysis being of little use to the clinician, who must take each case on its own merits.

PART II. DISEASES OF THE INTESTINES

CHAPTER XIV

TEST MEALS FOR THE INVESTIGATION OF INTESTINAL DISEASES —MILK, SCHMIDT'S, MIXED AND MEAT DIETS

APPARENTLY for æsthetic reasons, the examination of the fæces has been very much neglected by medical men in general, and in spite of the fact that it is impossible to diagnose some of the diseases of the bowel without a thorough examination of the fæces, our knowledge of the chemical composition of the stools under pathological conditions is very much less than our knowledge of the stomach contents in gastric disease. It is unfortunate that such should be the state of affairs, since many of the slighter forms of intestinal dyspepsia lead to alterations in the fæces, and the recognition of these is a considerable aid in making a diagnosis.

As a consequence of investigations into the fæces having been made so scantily, our knowledge is most imperfect, and it will be impossible for us to give more than a sketchy outline of the general alterations which occur in the stools in certain pathological states.

The fæces, as we know, consist of undigested and indigestible substances taken in the food; at the same time, they also consist of more or less changed digestive secretion which is poured into the alimentary canal, together with numerous bacteria, the bacteria of the fæces having been shown by Strasburger[1] to represent in health no less than one-third of the dry substance, while under pathological conditions the proportion may be very much larger.

[1] *Zeit. f. Klin. Med.*, 46, 1902, p. 413 and 48; 1903, p. 495.

Thanks to Strasburger and Schmidt, we have an excellent work "Die Fæces des Menschen," which comprises the general facts at present known as regards the analysis of the fæces.

The diet has a very marked influence on the appearance of the fæces, and in comparing the stools under pathological conditions, it is absolutely essential to have some fixed diet. We all know how widely the stools of an individual on milk alone differ from those of an individual on an ordinary mixed diet, and if the normal white stool which one sees on a milk diet occurred on a mixed diet, it would be pathological. The proper investigation of the fæces, therefore, necessitates certain diets being given, comparison being made of the fæces on these diets only. It is further necessary to keep the patient on the same diet for a period of three to five days, so as to obtain a normal motion on the special diet. In all chemical investigation of the fæces, whether in health or disease, it is necessary to collect all the motions belonging to a three- to five-day period, giving some indicator so as to isolate—both at the commencement and at the end of the period during which the diet is being taken—the stools passed on the fixed diet. The fæces are then collected from the first appearance of the indicator up to the time when the second dose is seen to appear in the stools. All the motions passed during this period are either separately analysed, or to save time, the whole may be analysed together after being thoroughly mixed.

With regard to the choice of diets for analysis, it is necessary to have a selection, so that one may suit individual requirements in the various pathological conditions. One must also bear in mind the necessity of providing the various ingredients (carbohydrates, fat, and proteid) in convenient quantities, and in a form which will be more or less easily utilised by the alimentary canal.

The diets which we have found the most useful for analytical purposes are four in number; these are found to simplify the normal standards for comparison, while providing sufficient variety to enable one to deal with patients suffering from divers diseases, in some of which a more substantial diet could not be tolerated.

I.—MILK DIET

Milk is the simplest of all diets, containing as it does, proteid, fat, and carbohydrates in a form comparatively easily absorbed, thus affording a diet which can be employed in cases of severe intestinal derangement where no other food could be given.

The milk is best given at two-hour intervals, the quantity being varied according to the weight and general condition of the patient. As a rule, ten ounces of milk every two hours from 8 A.M. to 10 P.M.—making a total of four pints in the twenty-four hours—is a suitable diet, and this contains 85·00 grams of proteid, 84·00 grams of fat, and 106·40 grams of carbohydrates, so that the individual receives a total of 1561·84 Calories in the twenty-four hours.

In cases where the patient is unable to take milk, and as predigested milk cannot be employed in the investigation of absorption, one must endeavour to get over the difficulty by decreasing the quantity, giving it hot or cold according to the idiosyncrasy of the patient, or adding a small measured quantity of lime or barley-water to each glass of milk. When the latter plan is adopted, it must be remembered that barley-water contains a certain amount of carbohydrates, and the carbohydrates thus obtained must be added to those contained in the milk itself in calculating the total Calories. In cases where the bulk of fluid is the patient's difficulty, the amount of nourishment in a given quantity of fluid may be increased by evaporating the milk to one-third its volume over a water-bath.

II.—SCHMIDT'S DIET[1]

7·30 A.M.—Milk 17½ oz. (or if milk is very badly borne, cocoa made from ⅔ oz. cocoa-powder, ⅓ oz. sugar, 1 oz. water, 3½ oz. milk), and 6 biscuits.[2]

9 A.M.—Gruel made from 1½ oz. oatmeal, ⅓ oz. butter, 7 oz. milk, 10½ oz. water, 1 egg, and 2 biscuits.

1 P.M.—4½ oz. (raw weight) minced beef, lightly fried in ⅓ oz. butter (so that the interior remains raw), and potato

[1] *Die Funktionsprüfung des Darmes mittels der Probekost*, &c. Wiesbaden, 1904, p. 7.

[2] Schmidt gives rusks, but we find it more convenient to employ Mackenzie's toast biscuits, the analysis of which is given in the Appendix.

purée made from 7 oz. mashed potatoes, 7 oz. milk, ⅓ oz. butter.

4·30 P.M.—Milk 17½ oz.

7·30 P.M.—Same as at 9 A.M.

This diet contains 118·00 grams proteid, 104·86 grams fat, and 204·48 grams carbohydrates, so that the total quantity given each day will be 2297·37 Calories.[1]

The advantage of Schmidt's diet over a simple milk diet is that it gives us various constituents of food more resembling a normal diet; at the same time, the food has not been so altered in the culinary process that the ingredients are difficult to recognise microscopically.

The fæces which are passed on Schmidt's diet can be very easily examined both microscopically and chemically, and it is undoubtedly a very useful diet in the investigation of most intestinal complaints. On the other hand, the diet has the very serious disadvantage that English patients, as a rule, object to taking it for many consecutive days. It cannot, therefore, be called a suitable diet for making metabolism observations.

III.—MIXED DIET

The mixed diet, which, after twelve years of experimental work on human metabolism, we find to yield the best results for the investigation of absorption and general metabolism of patients suffering from malnutrition, is as follows:

8 A.M.—10 oz. hot water.

9 A.M.—3 oz. whiting, 4 Mackenzie's toast biscuits, ⅓ oz. butter, 10 oz. tea, 2 oz. milk.

12 noon.—10 oz. hot water.

1 P.M.—3 oz. mutton, 3 oz. cabbage, rice pudding (½ oz. rice 10 oz. milk),[2] 4 biscuits, ⅓ oz. butter.

4·30 P.M.—10 oz. tea, 2 oz. milk, 2 biscuits.

6 P.M.—10 oz. hot water.

7 P.M.—3 oz. plaice, 3 oz. chicken, 3 oz. spinach, rice pudding (½ oz. rice 10 oz. milk), 2 biscuits, ⅓ oz. butter.

1 Schmidt gives 102 grams proteid, 111 grams fat, and 191 grams carbohydrates, with a caloric value of 2234 Calories, but our figures are the results of repeated analyses of the food-stuffs we employ.

2 This rice pudding is very fluid unless carefully prepared, and requires extra time in cooking; so that sometimes it is preferable to use only 8 oz. milk.

10 P.M.—10 oz. milk.

This diet contains 130·81 grams proteid, 72·19 grams fat, and 119·35 grams carbohydrates, so that 1697·03 Calories are given in the twenty-four hours.

According to the weight and appetite of the patient, the diet may be increased to 4 oz., or decreased to 2 oz. If it is desired to increase the Calories in a certain direction, the easiest way is to add a measured quantity of milk, taking as a standard that 10 oz. of milk contain 10·63 grams proteid, 10·50 grams fat, and 13·30 grams carbohydrates, making a total of 195·20 Calories.

For purposes of analysis, we give in the Appendix an analytical *résumé*, of the various food-stuffs employed in the mixed diet given for metabolism experiments. The tables given are based on averages obtained in numerous analyses, specimens of each article of diet having been taken before administration to the patient. By substituting another food-stuff for any article of food given in the above diet, the individual idiosyncrasies of patients may be suited.

The fæces on this mixed diet can easily be compared with one another, and for quantitative chemical analyses, it would appear to be the best suited. The diet is a more desirable one than Schmidt's, as the patients can be kept on it for a much longer period without being nauseated, and the results are, therefore, more accurate. The disadvantage of the diet is that in cooking, &c., the food is so much altered that microscopic examination does not give such definite results as are obtained in Schmidt's simpler diet.

We find it advisable in many cases to put the patient for a short period on Schmidt's diet, in order to give an opportunity of making a microscopic examination, and having a qualitative chemical examination of the fæces, and to follow this by a second test period on a mixed diet, during which a quantitative, as well as a qualitative, analysis can be carried out.

IV.—MEAT DIET

In some cases where the condition of the patient does not allow of Schmidt's diet or a mixed diet, and where one cannot give milk on account of some individual idiosyncrasy, we have found a simple meat diet to be useful. The patient takes ¼ to ½ lb. of finely minced beef every three or four hours, and one hour before each meals, 10 oz. of hot water.

The disadvantage of this diet is that the patient objects to taking large quantities of meat, and for this reason it is difficult to give sufficient Calories in the twenty-four hours to keep up the weight. By giving ¼ lb. of meat every three hours, one gets a total of 1 lb. of minced beef per diem, and this diet consists of 145·5 grams proteid, 31·08 grams fat and no carbohydrates, yielding a total of 885·59 Calories in the twenty-four hours.

CHAPTER XV

QUANTITY OF FÆCES, COLOUR, CONSISTENCY, AND ODOUR

In the organism of a healthy individual there are various factors which have a great influence on the quantity of fæces passed. V. Oefele [1] shows that a single motion may contain from 100 to 250 grams with thirty to forty grams of solids, while Lynch [2] describes a case of prolonged constipation in which no less than twenty kilos were passed.

The quantity of motion passed under ordinary circumstances varies from day to day, so that no conclusions can be drawn from the examination of a single stool, it being essential to take the average of a period of observation; the longer the period, the more accurate will be the conclusions drawn as to the average daily quantity. Individual sensations must not be taken as any indication of the quantity of stools passed, for it will be found that in most people the estimation of the quantity of fæces is influenced by the hardness of the motions, thus leading to a false and often exaggerated idea of the quantity passed.

The fæces, even during a period of fasting, are found to show individual variations. Cetti, during a ten days' fast, passed an average of no less than 22 grams of fresh fæces per diem, the fæces containing 3·4 grams of dried substance; while Breithaupt, during a six days' fast, passed 9·5 grams of fresh fæces containing 2 grams of dried substance (Fr. Müller).[3]

The age of the individual under observation has a marked influence on the quantity of fæces passed, as is shown in table XV.

It is seen that there is a general tendency to an increase in the daily quantity of fæces progressive with the age of the

[1] *Statistische Vergleichstabellen zur practischen Koprologie*, &c., Jen. G. Fischer, 1904, S. 58.

[2] *Coprologia Tesis*, Buenos Aires, 1896, p. 38.

[3] Berlin, *Klin. Wochenschr.*, 1887, p. 434.

patient under observation. It will be noticed that a child on ordinary cow's milk tends to pass a larger quantity of fæces than when sucking the breast. This is in great part due to the quantity of nourishment given; when artificial feeding is properly arranged, it has been found that the addition of cream in a child being reared on cow's milk will make the fæces more closely resemble those found on mother's milk.

TABLE XV.—INFLUENCE OF AGE ON THE QUANTITY OF FAECES[1]

Age.	Diet.	Average quantity of fresh fæces per diem.	Observer.
1 month	Mother's milk	3·3 grams	Camerer & Hartmann[2]
2–3 months	,,	6·5 ,,	,,
2–3 months	Cow's milk	51·6 ,,	Escherich[3]
7 months	According to the food	15–56 ,,	Various
9 months	Cow's milk	59 ,,	Camerer[4]
¾–2 years	Mixed	77 ,,	,,
4 years	,,	101 ,,	Camerer[5]
6 years	,,	134 ,,	,,
9 years	,,	117 ,,	,,
11 years	,,	128 ,,	,,
Adult	,,	131 ,,	Pettenkofer and Voit[6]

The frequency of the motions has a marked influence on the total quantity of fæces passed, and a diet which causes frequent motions tends also to increase the total quantity. It is well known that in health the kind of diet has a great influence on the stools, a diet rich in meat tending to cause constipation, while a diet rich in vegetables tends to increase the peristalsis of the bowel, causing more frequent stools and a larger quantity of fæces.

We have already shown how we prefer to employ one of four diets for the purpose of examination of the fæces under pathological conditions, and it is only necessary for us to describe the quantity of fæces found on these four diets, leaving further details, which are purely physiological, out of consideration.

1 Strasburger and Schmidt, *Die Fæces des Menschen*, p. 11.
2 *Zeitschr. f. Biologie*, xiv. 1878, p. 383.
3 *Jahrb. f. Kinderheilkunde*, xxvii. 1888, p. 104.
4 *Zeitschr. f. Biologie*, xxxix. 1899, p. 37.
5 *Ibid.* xvi. 1888, p. 33.
6 *Ibid.* ii. 1866. p. 488.

Quantity of Fæces on a Milk Diet.—In individuals on a milk diet, the quantity of fæces varies, according to our analyses, from 60 to 288 grams, the average being 133·3 grams. The quantity of milk given has a very marked influence on the quantity of fæces passed.

TABLE XVI.—QUANTITY OF FÆCES ON MILK DIET

Pints.	Cases.	Highest in grams.	Lowest in grams.	Average in grams.
4	8	277	60	135·2
$4\frac{1}{2}$	6	288	79	142·6
5	2	159	144	151·5
6	2	142	134	138·0

In Table XVI. we have put together observations in which the patient took 4, $4\frac{1}{2}$, 5 or 6 pints of milk per diem, and it is seen that the quantity of fæces passed on these quantities shows a tendency to increase with the increased quantity of milk.

Quantity of Fæces on a Schmidt's Diet.—On this diet, the quantity of fæces varies from 56 to 135 grams, the average being 89·8 grams, thus showing that Schmidt's diet tends to cause a smaller quantity of fæces than a simple milk diet.

TABLE XVII.—QUANTITY OF FÆCES ON SCHMIDT'S DIET

Cases.	Highest in grams.	Lowest in grams.	Average in grams.
8	135	56	89·8

Quantity of Fæces on a Mixed Diet.—The fæces on an ordinary mixed diet show a variation from 30 to 282 grams per diem, the average being 102·8 grams.

TABLE XVIII.—QUANTITY OF FÆCES ON MIXED DIET

Cases.	Highest in grams.	Lowest in grams.	Average in grams.
118	282	30	102·8

In discussing mixed diets in connection with examination of the bowel, we mentioned that the introduction of milk was the easiest method of increasing the Calories; it is as well, therefore, to give here the effect of increasing the quantity of milk in a mixed diet on the quantity of fæces. In Table XIX. the effects of the addition of 1½ pints, 2 pints, 2½ pints and 3 pints respectively are separately given.

TABLE XIX.—QUANTITY OF FÆCES ON MIXED DIET + INCREASING QUANTITIES OF MILK

Pints.	Cases.	Highest in grams.	Lowest in grams.	Average in grams.
1½	35	314	52	117·3
2	24	283	55	101·6
2½	12	282	82	137·6
3	5	225	65	139·4

It is seen that on 1½ pints of milk the quantity of fæces varied from 52 to 314 grams, yielding an average of 117·3 grams. When 2 pints were added to the ordinary mixed diet, the quantity of fæces varied from 55 to 283 grams, giving an average of 101·6 grams, showing a slight tendency to decrease in the average quantity. When 2½ pints of milk were added to the diet, the quantity of fæces varied from 82 to 282 grams, yielding an average of 137·6 grams, while on the 3 pints of milk, the quantity of fæces varied from 65 to 225 grams, averaging 139·4 grams. In making a general comparison of results, it will be seen that there is a tendency to increase in the quantity of fæces in proportion to the increased quantity of milk given.

Quantity of Fæces on a Meat Diet.—The quantity of fæces on a meat diet varied from 41 to 72 grams, the average of six cases being 54·5 grams. It will be noticed that this is a much smaller quantity than those found on the other diets which we employ in the investigation of diseases of the bowel.

TABLE XX.—QUANTITY OF FÆCES ON A MEAT DIET

Cases.	Highest in grams.	Lowest in grams.	Average in grams.
6	72	41	54·5

COLOUR, CONSISTENCY, AND ODOUR

Colour.—The colour of the interior of the fæces is not always the same as that found on the surface, so that it is important, when noting the colour, to have the motions thoroughly broken up.

The normal colour of the stools is in part due to the diet. On a mixed diet, the tendency is for the motions to be of a definite brown colour, while if meat preponderates in the diet, the colour may be blackish-brown, or even almost black. On a mixed diet containing a large quantity of vegetable matter, the colour tends to be light brown or greenish-brown. In the majority of cases, the green colour is due to chlorophyll which occurs when large quantities of cabbage, salad, or more especially spinach, are taken. Quincke has also shown that the lightness of colour on a vegetable diet is partly due to bubbles of gas which are entangled in the large amount of residue left. The green colour may be due to bacteria, while under pathological conditions, it can be caused by bile.

The colour of the fæces is also influenced to a certain extent by the length of time they have remained in the large intestine, since the normal absorption of water which occurs in the large intestine especially influences the surface of the fæces; so that one may note a darkening of the outer layer (due to the greater drying) and on moistening, the colour becomes distinctly lighter (Fleischer).

On a milk diet, on the other hand, the fæces are white or pale orange colour.

The colour of the fæces is not influenced by bile as such, since bile, as bilirubin or biliverdin, does not occur in normal motions. The colour is in great part due to urobilin, which has been formed from the bile in its passage along the intestine after it has reached the cæcal valve. On extracting the fæces with acid alcohol, one is able to remove the greater part of the urobilin, which is easily recognised by means of the spectroscope; but even after repeated extraction, the residue still has some colour.

As already stated, bilirubin as such is never normally present in the stools of adults, although in early infancy it is always present. In the ordinary breast-fed child, one gets a yellowish-coloured motion due to bilirubin which is very easily converted into biliverdin, and excreted as such when there is any disturbance of the digestion, in which case we get the green motion so commonly noticed in children. The conversion of the bilirubin into biliverdin would appear to be due to the acids (acetic and butyric acid) which are formed by the disturbed digestion. The green motions seen in children may, however, be due, not to biliverdin, but to the products of a special bacteria causing a green pigment.

In adults, biliverdin is never found in the motions except after calomel or under pathological conditions.

In cases where the bile duct is obstructed, one gets the well-known pipe-clay coloured stool which is in part due to the absence of urobilin from the fæces. The light-coloured stool found in jaundice is also partly due to the large amount of fat present in the stools; on extracting the fat with ether, one obtains brownish-coloured fæces due to the hæmatin residue of the meat diet.

That colourless stools may occur in the absence of obstruction of the bile duct was shown by Walker[1] in two cases, in both of which it was demonstrated that the bile ducts were patent; and it would appear that the absence of the pancreatic juices explains the deficiency of colour.

Dr. Walker drew attention to the fact that one may have colourless stools without any jaundice. In fact, the normal brown colour of the stools is due to the action of the pancreatic juice on the bile pigments. He described two cases:

(1) T. W., a medical practitioner, passed colourless stools for some twenty-four years. The stools were described as large, colourless stools with a peculiar putrid, rather than fæcal, odour. In course of time, the dejecta were accompanied by free oil or fat which floated either as liquid or solid substance on the surface of the water, and the stools themselves were greasy. During many years, the patient remained in good health, and then had a slight attack of pneumonia, during which he had some jaundice, with deep staining of the conjunctiva, skin, and urine, thus conclusively showing that when real obstruction to the bile ducts appeared, jaundice occurred. When on an exclusively milk diet, the motions were snow-white; they were usually the large, rather relaxed putrescent, greasy, clay-

[1] *Med. Chir. Trans.*, 1889, vol. lxxii. p. 257.

coloured stools noted at the commencement of the disease. At the age of ninety-one he died. At the autopsy, the liver was normal, the pancreatic duct was dilated, and, at the entrance to the duodenum, was blocked by an irregular calculus.

(2) The second patient passed some colourless stools, and at the autopsy, there was found to be no obstruction of the bile ducts, but the opening of the pancreatic duct was blocked by a duodenal cicatrix.

In some cases where there is no obstruction to the bile duct, and apparently no increased quantity of fat to cause a colourless motion, it would appear that the urobilin normally present in the fæces has been converted into leuko-urobilin which is colourless, and after exposure to the air, gradually becomes by oxydation reconverted into urobilin, giving a coloured motion.

Medicaments may influence the colour of the stools. As is well known, one gets, after bismuth, black fæces; this used to be considered due to the sulphide of bismuth, but as Quincke[1] has now shown, it is really due to the reduction of the bismuth sub-nitrate to bismuth sub-oxide. Calomel also influences the fæces by causing an increased excretion of bile, hastening the bile along the alimentary canal and, in some cases, allowing the biliverdin to be eliminated as such, instead of as urobilin. Rhubarb, senna, and satonin cause yellowish-coloured stools which, on being rendered alkaline, become more red.

Consistency.—The consistency of the fæces, in absence of disease of the bowel, depends on: (1) The amount of water present; (2) the amount of fat present; (3) the amount of mucus present; (4) the amount of indigestible remains of vegetable matter.

The stools may be formed, and if hard, are more or less in the shape of sausages, the size of the sausage depending upon the size and tone of the anal orifice. If the rectum is narrowed by stenosis, one may get pencil or ribbon-like motions. It has been shown by Boas [2] that in true stenosis of the bowel, it is much more common to get a pultaceous motion containing some long or short pencil-like cylinders than the narrow fæces alone. This

1 *Vortrag in der Sitzung des physiolog. Vereins zu Kiel am*, 13, vii. 96.—*Referirt Münch, med. Wochenschr.*, 1896, p. 854.

2 *Diagnostik u. Therapie der Darmkrankheiten*, Leipzig, 1898; vol. i. pp. 95 and 96.

alteration in shape is not conclusive evidence of narrowing of the rectum or anal orifice; in simple muscular spasm of the muscles of the rectum or the anal orifice, or in paralysis of the lower part of the large intestine, one gets some appearance of pencil-like motions. The diagnosis is at once cleared up by the insertion of the finger into the rectum.

Large, sausage-like motions are often found to be made up of small balls massed together, while in other cases one has a cylinder with one or two balls pressed into it. These scybala coming from the sacculi coli are remains of some previous days' food, this being easily demonstrated when charcoal has been given.

The formed motions in constipation tend to be less and less sausage-shaped, and more and more like sheeps' motions, the fæcal balls having facets, while in chronic constipation the balls may become more and more isolated until one gets distinct round balls or typical scybala. These scybala are due to the long delay in the large intestine, and point to imperfect power of contraction of the muscles of the large intestine.

Loose motions may be divided into pultaceous motions like those passed by cows, and watery motions which one gets in cases of diarrhœa. There may be all kinds of gradations between the pultaceous and the serous exudations which one gets in cholera. It can be easily understood that, in cases of diarrhœa, it is not at all uncommon to find a pultaceous, or even a fluid, motion mixed up with some scybala, the explanation of which has already been given.

It must be recognised that the pultaceous motion, when not due to excess of fruit or vegetables in the diet, fat in the stools, or aperients, is always pathological. The quantity of fat or mucus in the stools has a great influence on the softness of the motions, but these alterations will be considered in discussing the pathological cases.

The brittleness of the motion depends, to a certain extent, upon the equal mixture of its constituents. When milk is well digested, one gets a very tenacious motion, while, when lumps of casein are left owing to imperfect digestion, the motions become less coherent. Again, in fasting or on a pure meat diet, the motions are very coherent. Where vegetables are given, leaving a large amount of cellulose residue, one often gets more or less brittle fæces.

Odour.—The distinctive smell of fæces is due to the skatol and small degree of indol normally present in them. Skatol and indol are derived from the putrefaction of proteids in the large intestine, and therefore the degree of odour present in the fæces is dependent on the quantity of proteids in the diet, and the quantity of putrefactive bacteria present in the large intestine. On a milk diet in health, smell is almost absent in consequence of the very small quantity of proteid reaching the large intestine. A milk diet, when fermentation takes place in the intestine, is very apt to cause acid-smelling fæces, due to the presence of acetic and butyric acid.

Motions which contain a large amount of mucus often have a seminal smell, which is very characteristic, though difficult to explain.

Under certain conditions, the fæces have a putrid smell, quite distinctive from indol and skatol; this very often occurs in malignant disease of the bowel, and also in dysentery.

Having briefly described the general characteristics of the fæces so far as colour, consistency, and odour are concerned, we can now group together the microscopic appearance of the fæces in individuals taking one or other of the four diets which we employ in observation of bowel disease.

Colour, Consistency, and Odour on a Milk Diet.—The colour of the fæces on a pure milk diet tends to be yellowish-white or white tinged with orange. As a rule, the fæces are not so well formed as those on an ordinary diet, and the rolls show a tendency to have small lumps cemented together, while in other cases the firm sausage-shaped stool is accompanied by some soft paste. The hard white fæces passed on a milk diet very often show a distinct pink shade of colour in patches on the outside of the lumps or rolls, due to the products of bacteria.

In constipation, the fæces on a milk diet take the form of sheeps' motions or isolated scybala. Where the latter are present, they are often so hard that they rattle like stones when in a jar, and on breaking them up in a mortar they show marked resistance, the pieces flying apart as though dry clay pellets were being broken up. In such cases, it is not at all uncommon to notice a definite earthy smell.

In diarrhœa on a milk diet, the appearance of the fæces resembles Devonshire cream, the consistency being such that they can be poured from the jar into a capsule in a thick, slimy mass, leaving a considerable quantity sticking to the glass. Bubbles of gas are seen on the surface, and on shaking the fæces, they will become very frothy. The odour of fæces in diarrhœa often resembles that of decomposed cheese, while in other cases they may smell like putrid proteid.

Colour, Consistency, and Odour on a Schmidt's Diet.—The fæces, on a Schmidt's diet, are generally of a light, brownish-yellow colour, tending to a darker colour on the outside than is found in the interior. Usually they are well-formed rolls, while in some cases there are formed lumps or scybala. The odour of the fæces on Schmidt's diet is peculiarly earthy. The fæces are frequently brittle, and are easily broken up into a fine powder on drying. In fact, they are more brittle and more easily broken up than any fæces we have examined.

In constipation, the fæces on Schmidt's diet consist of lumps massed together into sheep-like motions, or scybala faceted or isolated as in other diets.

In diarrhœa, the fæces on a Schmidt diet resemble those found on a milk diet.

Colour, Consistency, and Odour on a Mixed Diet.—The fæces on a milk diet are generally nut-brown or olive-green in colour. The latter is, as has already been explained, due to the chlorophyll from the vegetables given in the food. From day to day the colour varies considerably; for instance, in one day on a mixed diet, one may get distinctly brown fæces, and on another day green, or perhaps a mixture of the two, while, on a third day, they may be a dirty slate colour. The motions on a mixed diet are generally in the form of a sausage about 1½ in. in diameter, and it is not at all uncommon to find, joined to these rolls, small round or flattened lumps firmly embedded in the mass. On being dried, the firm normal fæces on a mixed diet are rather brittle, easily broken up and ground down in a mortar. On the other hand, when one gets pasty or fluid fæces on a mixed diet, they tend on drying, to become hard and glassy, with almost the appearance of flint, and can only be ground down with great difficulty.

In constipation, the fæces on a mixed diet are dark brown or black scybala, showing pressure facets; mucus is generally found in the crevices between these lumps. In some cases, the scybala are so hard that they resemble stones, and rattle like the constipated fæces on a milk diet. The lumps are extremely difficult to break down when well-formed scybala are present. The odour of these fæces is generally not very distinctive of skatol and indol.

In diarrhœa, the fæces are very dark-brown, nearly black; the consistency is that of thick paste, and floating about in this thick paste are small rolls or scybala about one to two inches in diameter. The fæces are very sticky, and sometimes adhere closely to the glass jar. Soft paste and fluid motions present on a mixed diet have generally a very offensive odour.

The fæces in a mixed diet to which considerable quantities of milk have been added in order to raise the Caloric value, tend to be of a light-brown colour, and according to the quantity of milk added, resemble more and more the fæces seen in a milk diet. The consistency is never so firm as that of fæces in an individual on a mixed diet, without the addition of milk.

Colour, Consistency, and Odour on a Meat Diet.—The colour of the fæces on a meat diet is very dark brown, almost black. The consistency tends to be very firm, the rolls varying in length. As a rule they are not longer than two or three inches, and are generally quite separate from each other. The odour on a pure meat diet is that of skatol and indol, and under normal circumstances, is not very offensive.

CHAPTER XVI

GENERAL EXAMINATION OF FÆCES, MACROSCOPIC AND MICROSCOPIC

After having noted the colour, consistency, and odour of the fæces, it is necessary to make a general examination, and for this purpose, it is advisable, after well mixing the fæces, to divide them up, reserving the greater part for chemical analysis and a smaller portion for macroscopic and microscopic examination,

MACROSCOPIC EXAMINATION

A portion about the size of a walnut is put into a mortar, and by slowly adding water and grinding, the whole is brought to a pea-soup consistency. It is well to have a glass dish, one half of which is coloured black, and to pour the pea-soup-like mixture into the dish. On running it about over the surface, one gets a very good idea of the residue or particles of mucus that may be left after breaking up the fæces. The examination will show particles of mucus, fibrin, &c., connective or muscular tissue, and any remnants of vegetable matter, and the particles can be taken out if desired, and mounted on a slide for microscopic examination.

Mucus will only be recognisable under pathological conditions, and if found to be coloured yellow with bilirubin, it will indicate that the mucus comes from the small intestine, while that coming from the large intestine or the rectum will be very slightly yellow, or more probably white. Floating about in the fæces may be seen small sago-like bodies resembling frog-spawn, which used to be attributed to mucus coming from the intestinal follicles, but are now known to be the remains of vegetable matter. These sago-like bodies have only been found by us after a mixed diet; and in individuals who have been taking a large quantity of vegetables, they are almost invariably present in the fæces. They have no pathological significance.

Connective tissue or remains of tendon will be found in some cases where minced meat has been given, or a diet containing under-cooked meat. The macroscopic appearance of this connective tissue very much resembles that of mucus, but if small particles are put under the microscope, they can be distinguished from mucus by the addition of acetic acid, which removes the striation from connective tissue, while in the case of mucus it produces striation. Small quantities of connective tissue are occasionally found under normal conditions, but when large quantities are present, it points to insufficient digestive power of the stomach. The residue of muscular fibres can occasionally be seen by the naked eye as small brown or reddish-brown points, which will be immediately recognised under the microscope. If large quantities of meat have been given in the diet, these remains of muscle will be found in normal digestion, but on the ordinary test-diet, more especially the mixed diet, any muscular tissue which can be easily recognised by the naked eye must be considered pathological, and points to disturbance of the digestive power of the small intestine.

Ammonium magnesium phosphate, or triple phosphate crystals are, in some cases, so large as to be seen macroscopically. They are not present on an ordinary test-diet, if the fæces examined are perfectly fresh; if, however, the fæces have been passed one or two days before examination, they are nearly always present, especially if the fæces tend to be alkaline, or if there is increased putrefaction. They probably have no pathological significance.

Blood or pus can often be recognised in the thin layer floating on the black half of the dish, or on the transparent half, if held up to the light. Remains of undigested particles of food, bones, bits of egg-shell, cellulose, or intestinal worms can also be recognised by the naked eye.

MICROSCOPIC EXAMINATION

For the microscopic examination of the fæces, it is well to prepare three or four slides to receive the pea-soup-like mixture.

Muscular fibres will be easily recognised under the microscope; their significance, when large quantities of meat have been given in the diet is very slight, but when only small quantities of meat have been taken, their presence is indicative of disease of the alimentary canal. If muscular fibre is found distinctly striated, it is evident that intestinal digestion is hindered.

The recognition of connective tissue under the microscope is merely confirmatory of its observance by the naked eye.

On a milk diet, when the digestion is disturbed, it is not at all uncommon to find small flocculi of casein which will be easily recognised, showing a distinct tendency to disturbed intestinal digestion.

Yellow lumps, as described by Nothnagel, are very often found. They can sometimes be seen by the naked eye, having the appearance of small yellow points the size of a small pin's head. Under the microscope, they will be seen to consist of irregular-shaped masses of structureless yellow substance, very often surrounded by mucus. On the addition of sodium hydrate they slowly dissolve, the solution being much hastened by heating. On the addition of acetic acid, these structureless masses swell up, and if ferrocyanide of potassium is added, yield a white precipitate. On the addition of Millon's solution and heating, one obtains a red colour.

From the microchemical examination of these yellow lumps it would appear that they are of an albuminous nature, and coloured with bilirubin. The fact that they are coloured with bilirubin, and not with urobilin, shows that a normal reduction of bile is not being carried on in the intestine, and, since the yellow masses are so often embedded in mucus, and since they do not occur in normal motions, they are evidently significant of some inflammatory affection of the small intestine accompanied by mucus formation.

Fat, if present in large quantities, would be recognised macroscopically; microscopically, one can recognise smaller quantities, and in nearly all specimens of fæces, a certain amount will be found to be present. If the fat has a low melting-point, one will find it in the form of drops, while the higher melted fats will be in regular flakes. On heating the slide, the neutral fat will melt, and, on cooling again, form drops which will be easily dissolved by hot alcohol, ether or chloroform, and will be unaltered by the addition of sodium hydrate.

Fatty acids will be found partly in flakes, but much more easily recognised in the needle-like crystals, which will give the same reaction as the neutral fat, except that they are easily soluble in cold alcohol and sodium hydrate. The soaps also appear in the fæces, partly in flakes and partly in crystals. Soap flakes are less shiny, of a firmer consistency, and have sharp corners, so that, practically, one is able to distinguish them from the fatty acid or neutral fat flakes. They are easily dissolved in hot water or alcohol, and on warming the preparation, they melt in the same manner as the fatty acids and the neutral fats.

Under normal circumstances, one finds, on a meat diet, some fat drops, while crystals of fat or fatty acids are rarely present on the ordinary test-meals; the presence of soaps is also not characteristic of any special pathological condition, unless we find them coloured with bilirubin, instead of urobilin; this condition will indicate diminution in the reduction of bile in the intestine.

It is not at all uncommon to find remnants of starch in the fæces by the aid of the microscope, on using chemical tests. The ordinary method of testing for starch is by adding a solution of potassium iodide iodine, when the starch will become indigo black. When any quantity of potato or other starchy food is given in the diet, one obtains a very distinct colour reaction with iodine. It is extremely difficult to say what degree of starch in the fæces one ought to consider pathological, and a diagnosis of want of carbohydrate absorption or breaking-up is probably better made by Schmidt's fermentation test.

Ammonium magnesium phosphates are the commonest crystals found in fæces, and are never coloured by bile; and, as we said when discussing the triple phosphate crystals macroscopically, they are in some cases so large that they can be detected in the process of grinding. Crystals of triple phosphate are easily soluble in dilute acetic or other acids, and on the addition of ammonium solution, the crystals reappear. They are uninfluenced by the addition of ammonium carbonate solution and are thus distinguished from the basic magnesium phosphate.

Neutral phosphate of lime crystals (di-calcium-phosphate) are not at all uncommon in the fæces, and are occasionally stained by the bile pigments, which never occurs with the ammonium magnesium phosphate crystals. They are soluble in all acids and ammonia. Their significance seems to be practically the same as that of the ammonium magnesium phosphates.

Calcium oxalate crystals are extremely common on a mixed diet. In fact, if large quantities of vegetables are given, one finds in nearly all instances these characteristic crystals in the fæces. On a meat or milk diet they are usually absent. Therefore, when large quantities of vegetable have been taken in the diet, they have no pathological significance, but if no considerable quantity of vegetable has been given, their presence in any great number points to some intestinal dyspepsia.

Cholesterin crystals are very often recognised in the fæces by the aid of the microscope; they are so characteristic that the chemical reaction need not here be given.[1] The more careful the examination of the fæces, the more often cholesterin will be found, and it would appear that, in all cases where there is any great increase in mucus excretion, cholesterin is always present.

Charcot-Leyden's crystals, which are so easily recognised by their characteristic shape, are often found in the fæces, embedded in mucus. It used to be thought that the presence of these crystals was especially characteristic of the presence of intestinal parasites, but this is not the case. One finds intestinal worms when Charcot-Leyden's crystals are not to be recognised, and *vice versâ*. Charcot-Leyden's crystals are also found not uncommonly embedded in the mucus of membranous enteritis, and they would appear to have no special significance.

Various forms of epithelial cells and leucocytes are found in the fæces, and these are of great value in helping to make a diagnosis. When mucus-containing fæces, microscopically examined, show that the mucus contains numerous leucocytes or epithelial cells, one obtains very conclusive evidence of catarrh. In some cases where the epithelial cells show very little sign of breaking down or digestion, one may consider that the catarrh is in the rectum or lower part of the bowel, while in cases where the epithelial cells are very much broken up, one may make a diagnosis of catarrh in the small intestine. In our experience, the examination of the epithelial cells found microscopically in the fæces has been of little use in helping to locate the position of the catarrhal process; the presence or absence of bile-stained mucus is a much better indicator of the situation of the catarrh. It will be found that in catarrh

[1] The chemical tests for cholesterin will be found under Gall Stones.

of the small intestine—unless there is constipation—mucus or some of the soaps present in the fæces will be coloured with bilirubin, or in some cases, with biliverdin.

It is unnecessary to describe the other tissue substances or foreign bodies which may be present in the fæces, as one's own common sense tells one that any undigested residue swallowed by the mouth will in process of time and under ordinary circumstances, appear in the fæces; the pathological significance, therefore, of such substances as small particles of bone (more especially fish-bone) being found in the fæces is nil. It would appear that it is possible for some of the finer bones to be absorbed or broken up in their passage along the alimentary canal, but as the quantity of bone capable of being thus absorbed cannot be determined, the recognition of fish-bones in the fæces yields no evidence of diminished digestion.

CHAPTER XVII

CHEMICAL EXAMINATION OF FÆCES—REACTION, WATER, AND SOLIDS

In investigating diseases of the intestine, the chemical analysis of the fæces is most important. It is unnecessary for us here to discuss the various chemical processes which go on in the intestinal tract, and the alterations which take place in the food in its passage along the bowel, due to the action of the bile or pancreatic secretions or intestinal juices. For, although it is of great importance to know what is going on in the intestine itself, we are only here interesting ourselves in making a diagnosis on the alterations which are found to occur in the fæces, due to pathological changes in the intestine.

Reaction.—The reaction of the fæces varies, according to the diet taken, both in health and disease, and although the reaction itself is not of great importance in making a diagnosis, it gives certain evidence of changes going on in the bowel itself, the knowledge of which may be useful. At the present moment, our knowledge of the reaction of the fæces is very limited, and it is considered sufficient to know whether the fæces are alkaline, acid, or neutral. Quantitative alterations in the acidity oralkalinity have not up to the present been much utilised.

Method.—In the examination of the fæces, it is necessary to remember that the reaction of different parts of the motion varies, and it is not at all uncommon to find that the surface reaction is quite different from that of the centre, so that, in making any observations on the reaction of a stool, it is necessary to mix the fæces thoroughly before testing. Certain changes take place in the stool on keeping, and the reaction may become more acid or more alkaline as the case may be; it is therefore essential in noting the reaction of a motion to examine it as fresh as possible.

If the fæces are fluid, it will be sufficient simply to mix them well, but in the case of solid motions, it is as well to rub up the fæces in a mortar with distilled water until they assume a pea-soup consistency, and use this mixture for testing the reaction. It will then only be necessary to dip a glass rod into the mixture, and apply it to some red or blue litmus paper which has been previously moistened; one can then easily note the reaction on the reverse side of the paper.

The different indicators, such as cochineal, methyl orange, phenophthalein, &c., being very sensitive to certain bases or acids, will often give a reaction entirely at variance with that found with litmus. At the same time so little has been done in practice with the different indicators that for ordinary purposes, the litmus reaction is considered sufficient.

Quantitative Estimation of Alkalinity or Acidity.—Twenty to fifty grams of fresh fæces are well mixed and ground up in a mortar, as described in the macroscopic examination of the fæces, ten volumes of water being added. The mixture thus prepared is then titrated by allowing one tenth normal solution of sodium hydrate or one-tenth normal hydrochloric acid solution—according to whether the fæces have previously given an acid or an alkaline reaction—to run in with frequent stirring, until, by employing a glass rod, the litmus paper gives a neutral reaction. The tested acidity or alkalinity can easily be calculated by multiplying by five if twenty grams of fresh fæces have been used, or by two if fifty grams have been employed.

Reaction in Health.—There is a variation in reaction even in normal stools. As a rule, however, they deviate only very slightly from the neutral reaction.

Meconium, or fasting stools—which may both be regarded as the normal products of the excretions from the alimentary tract unvitiated by any food residue—give a faintly acid reaction, owing to the large quantity of fatty acids which they contain.

The diet has a great influence on the reaction of the fæces, so it will be well to make a few observations with regard to the normal reaction found on the four test diets which we employ in the examination of the fæces for the investigation into the condition of the intestinal tract.

Reaction on a Milk Diet.—The reaction of infants' fæces differs according to whether they are fed with human or cows' milk. The normal reaction of the fæces of a breast-fed child is faintly acid owing principally to the preponderance of lactic acid, and in less degree, of the other volatile fatty acids. The fæces of a child brought up on the bottle usually give a neutral or very faintly alkaline reaction, owing to the increased amount of casein present in cows' milk. At the commencement of most of the minor intestinal troubles in children, one gets a very marked acid reaction, owing to the formation of lactic and butyric acid. In more complicated intestinal disease such as enteritis, intestinal tuberculosis, typhoid, dysentery, and cholera, the fæces of a child give a distinctly alkaline reaction owing to the putrefaction of the proteids causing an excess of ammonia, and, at the same time, are very foul-smelling.

The normal fæces yielded by a milk diet in an adult give a neutral or very faintly alkaline reaction. Pathological alterations in the bowel cause, in adults, similar changes in the reaction of the fæces to those found in children.

Reaction on Schmidt's Diet.—The reaction of the fæces on Schmidt's diet is neutral or very faintly acid, where there is a healthy condition of the intestine. In cases where there is a tendency to intestinal fermentation, causing imperfect breaking-down of the carbohydrates and the formation of lactic and butyric acids, the stools, as a rule, are acid. In increased putrefaction, where the effect of the bacteria in the large intestine is to cause excessive breaking down of the proteids with increased formation of ammonia, the fæces will give a distinctly alkaline reaction.

Reaction on a Mixed Diet.—On an ordinary mixed diet with a fair digestion, the reaction of the fæces is very uniform, and there should be only a very slight deviation from the neutral, or very faintly alkaline reaction. The tendency to alkaline reaction on a mixed diet is due to the putrefaction of the proteid, which causes formation of ammonia. An acid reaction is, however, produced where there is any increased breaking down of carbohydrates, leading to excess of lactic or butyric acids. Schmidt[1] found that on a diet rich in starch, the total acidity equalled 80, while the same stool, after standing in a hot-air

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 108.

cupboard at 37° C. for twenty-four hours, showed an acidity of 320. This illustrates the importance of examining the fæces in a fresh condition. Increased quantities of fat in the diet, or insufficient absorption of fat, often lead to an acid reaction of the fæces, owing to the excess of fatty acids in the stools.

In diseases of the stomach, if not complicated by intestinal disorder, the reaction of the fæces remains neutral. Obstruction of the bile-ducts causes a markedly acid stool, owing to the decreased absorption of fat. When the pancreatic secretion is absent—although there is an increased quantity of fat in the stools, due to the greatly decreased breaking-up and absorption of the fats—the presence of the excess of fatty acids, which would otherwise cause an acid reaction, is masked by the increased putrefaction of the proteid, so that the stools are strongly alkaline. In intestinal disturbance resulting from the imperfect digestion of carbohydrates, leading to the formation of lactic and butyric acids, one obtains an acid reaction.

Reaction on a Meat Diet.—On a meat diet, the reaction of the fæces is, as a rule, faintly alkaline, or it may be markedly so, owing to the increased quantity of ammonia formed by the breaking down of proteid in the large intestine.

WATER AND SOLIDS

The casual examination of the fæces gives a very misleading idea of the quantity of water present in any specimen, for one sees more or less fluid motions due to the increased quantity of mucus, or even to some of the low-melting fats, which are accompanied by no increase in the quantity of water as evidenced by analysis.

Method of Estimating the Quantity of Water in the Fæces.—The estimation of the quantity of water in the fæces is not so simple as would at first sight appear. The fæces have to be dried down to some constant temperature which must not be too high, as otherwise, in obtaining dryness, one is apt to drive off volatile substances, and the weighing of the residue gives no true indication of the actual loss of weight which is due to water alone. In practice, it is advisable to take a small quantity of well-mixed fæces in a capsule and dry them over a water-bath with continual stirring. When they have thus been rendered as dry as possible, the capsule should be placed in an oven kept at some fixed temperature for a certain number of hours, after which it is placed over sulphuric acid in a desiccator, allowed to cool, and then weighed. This is repeated till the capsule remains at constant weight. We obtain the best results by keeping our drying cupboard at 60° C., using this as our constant temperature for obtaining standards of comparison.

If the fæces contain a large quantity of fat, it will not be possible to dry them by this method; it is essential in such cases to mix the fæces, previous to drying, with a weighed quantity of sand, which has been prepared by extracting with water, alcohol, and ether. This addition of sand will greatly simplify the drying, the method being otherwise as above described.

Quantity of Water in the Fæces under Normal Conditions.—The quantity of water in the fæces is influenced by the activity of the large intestine and the diet taken, so that, before discussing the quantity of water present in the fæces on our test meals, it is necessary to make a few remarks on the factors influencing the dryness of the fæces.

A diminution in the quantity of water in the fæces is produced by any stagnation of the intestinal contents in their passage along the large intestine, since the greater quantity of water is absorbed from the fæces during its passage along the colon.[1]

Stagnation of the intestinal contents may be due to diminished peristalsis or insufficient stimulation of the mucous membrane. This takes place when the food leaves little residue, as, for example, in fasting, on a pure meat diet, or milk diet. Diminished peristalsis of the large intestine may also be attributable to the insufficient action of the muscles of the bowel, such as occurs in simple neurasthenia, or want of accustomed exercise in people confined to bed from whatever cause. Dryness of the fæces may also be due to increased absorption of water by stimulation of the epithelium covering the mucous membrane of the large intestine; this is the apparent explanation of the dry fæces which occur in some cases at the commencement of taking certain alkaline springs.[2]

1 Vaughan Harley, "The Influence of the Removal of the Large Intestine and Increased Quantities of Fat in the Diet on General Metabolism in Dogs."—*Proc. Roy. Soc.*, vol. lxiv. 1898.

2 Hoppe-Seyler.—*Physiol. Chemie*, Berlin, 1881, p. 363.

An increased quantity of water in the fæces may be due to diminished absorption of water, arising from insufficient activity of the water-absorbing function of the epithelium of the mucous membrane of the large intestine. Insufficient activity of the epithelium of the large intestine may be produced in malnutrition, and also when the chymus has been pathologically altered so that salts with high water co-efficient are present in the intestine, or when certain medicinal salts are taken which cause an increased quantity of water in the fæces.

All abnormal intestinal contents appear to stimulate peristalsis, and the more irritable the mucous membrane of the intestine, the less the stimulant necessary to cause increased peristalsis, so that in inflammatory or in nervous (central) conditions, one frequently obtains an increased quantity of water in the fæces.

In all inflammatory conditions of the mucous membrane of the intestine, one sees, in addition to increased peristalsis, a tendency to an increased excretion of fluid from the mucous membrane itself, and at the same time, a secretion of mucus, which together give rise to an increased quantity of water in the fæces. In diseases of the small intestine, inflammatory products are often no longer recognisable in the fæces; one gets an increased quantity of water, and it is impossible to say whether it is due to exudation or to transudation. The increased quantity of water in the stools of cholera—Schmidt[1] describes cases in which only 1·2 to 1·5 per cent. of dry substances were found in the stools—is considered to be principally due to transudation, in the same way as the watery stools which occur after taking senna appear to be due to exudation. If one finds, together with an increased quantity of water in the fæces, inflammatory products from the mucous membrane, such as epithelial cells, mucus, pus, or blood, one may consider the condition to be probably due to exudation, while, if one finds increased epithelial cells and flocculi of epithelial cells (as in cholera) indicating the destruction of the surface layers of the mucous membrane, one may consider the condition to be due to transudation.

With these preliminary remarks, we may now go on to consider the quantity of water usually found in fresh fæces. In the cases which we have examined, the quantity of water has varied from 57·8 to 93·9 per cent., and in health on

[1] Strasburger and Schmidt, *Die Fæces des Menschen*, p. 113.

ordinary diets one may consider that the quantity varies from 70 to 80 per cent., giving an average of about 75 per cent.

Quantity of Water present in the Fæces on a Milk Diet.—As we have already shown, the quantity of water in the fæces is partly dependent on the amount of residue left in the chymus; on a milk diet, therefore, which leaves very little residue, one would expect a decrease in the quantity of water. At the same time, milk contains a large quantity of fat, and this has an influence on the quantity of water in the fæces, increased quantities of fat tending to increase the total quantity of water in the fæces.[1]

TABLE XX.—PERCENTAGE OF WATER NORMALLY PASSED IN THE FÆCES ON A MILK DIET

Milk in pints.	Number of cases.	Highest per cent.	Lowest per cent.	Average per cent.
4	6	81·23	73·45	76·99
4½	4	83·96	71·74	76·00
5	2	83·93	74·71	79·32
6	2	73·52	73·06	73·29

We have put together in Table XX. the results obtained on a milk diet in individuals who apparently suffered from no intestinal derangement. It will be seen that the quantity of milk daily taken causes an alteration in the quantity of water present in the fæces. When four pints of milk were given daily, the largest quantity of water found in the fæces was 81·23 per cent., and the lowest quantity 73·45 per cent., the average of the six cases being 76·99 per cent. In four normal individuals taking 4½ pints of milk per diem, the highest quantity of water present in the fæces was 83·96 per cent., and the lowest 71·74 per cent., the cases yielding an average of 76·00 per cent. In these cases, the increase of ½ pint of milk per diem had no tendency to increase the average quantity of water in the fæces. In two individuals to whom five pints of milk were given daily, the highest quantity of water found in the fæces was 83·93 per cent., while the lowest quantity was 74·71 per cent., giving an average of 79·32 per cent., thus showing

1 Vaughan Harley, *loc. cit.* p. 283.

a tendency to increased quantity of water in the fæces when the increased quantity of milk was given in the diet. In two further individuals, the quantity of milk was increased to six pints per diem, when the maximum quantity of water in the fæces was 73·52 per cent., and the minimum quantity 73·06 per cent., giving an average of 73·29 per cent., so that, in these two cases, there appeared to be no increased quantity of water in the fæces consequent on the increased quantity of milk given in the diet. In reviewing all the cases, we note a general tendency to increase in the quantity of water in the fæces, consequent

TABLE XXI.—PERCENTAGE OF WATER NORMALLY PASSED IN THE FÆCES ON SCHMIDT'S DIET

Number of cases.	Highest per cent.	Lowest per cent.	Average per cent.
6	83·15	71·66	75·95

on increased quantities of milk given in the diet. This is probably partly explained by the increased quantity of fluid taken, which undoubtedly has some influence on the quantity of water in the fæces, but the increase is principally due to the increased amount of fat taken in the diet, leading to an increased quantity of water in the stools.

Quantity of Water in the Fæces on Schmidt's Diet.—We have put together in Table XXI. the results obtained on a Schmidt's diet in six individuals who apparently suffered from no intestinal disorder. We see that the maximum quantity of water found in the fæces was 83·15 per cent., while the minimum quantity was 71·66 per cent., the cases yielding an average of 75·95 per cent. In discussing the Schmidt diet, we have already shown that it is a diet very easy of assimilation and absorption, and, therefore, one leaving little residue to cause stimulation of the bowel and increased peristalsis. At the same time, this diet is not so rich in fat as a milk diet, and this is the partial explanation of a smaller average of water being found in the fæces on a Schmidt diet than on a residue-free diet, such as milk.

Quantity of Water in the Fæces on a Mixed Diet.—In eighty-seven cases (Table XXII.) on an ordinary mixed diet in which no milk was given as such, but merely in the form of puddings, &c., the maximum quantity of water in the fæces was 83·21 per cent., and the minimum quantity 67·60 per cent., the cases giving an average of 75·72 per cent. It is thus seen that

TABLE XXII.—PERCENTAGE OF WATER PASSED IN THE FÆCES ON A MIXED DIET

Number of cases.	Highest per cent.	Lowest per cent.	Average per cent.
87	83·21	67·60	75·72

on the mixed diet which we employ in the examination of the bowels, there is very little residue to stimulate intestinal peristalsis, with the result that the quantity of water found in the fæces very much resembles that found on a Schmidt diet.

Quantity of Water in the Fæces on a Mixed Diet and Increasing Quantities of Milk.—We have already pointed out that fat has an influence on the quantity of water present in the fæces, and it is necessary, in comparing the quantity of water found in the fæces of patients on a mixed diet, to have some idea of the increase caused by adding milk to the diet, when this has been done to increase the Caloric worth of the patient's rations.

TABLE XXIII.—PERCENTAGE OF WATER PASSED IN THE FÆCES ON A MIXED DIET + INCREASING QUANTITIES OF MILK

Milk in pints.	Number of cases.	Highest per cent.	Lowest per cent.	Average per cent.
1½	28	82·65	65·42	74·57
2	21	81·09	68·45	73·79
2½	11	82·18	68·10	74·30
3	5	83·21	74·80	79·19

In twenty-eight cases (Table XXIII.) in which 1½ pints of milk were given in addition to the ordinary mixed diet, the maximum quantity of water in the fæces was found to be 82·65 per cent., and the minimum quantity 65·42 per cent., the cases giving an average of 74·57 per cent.

On increasing the quantity of milk to two pints daily, in twenty-one cases, the highest quantity of water in the fæces was 81·09 per cent., and the lowest 68·45 per cent., the average in these twenty-one cases being 73·79 per cent.

A further increase of milk to 2½ pints daily in eleven cases was seen to yield a maximum quantity of water of 82·18 per cent., and a minimum of 68·10 per cent., the eleven cases giving an average of 74·30 per cent. of water found in the fæces.

In five cases the quantity of milk was increased to three pints per diem, and in these cases the highest quantity of water found in the fæces was 83·21 per cent., and the lowest 74·80 per cent., the average being 79·19 per cent.

On reviewing these cases in which increasing quantities of milk were added to an ordinary mixed diet, we find a general tendency to increase in the quantity of water found in the fæces, if we take into consideration the progressively diminishing number of cases on increased quantities of milk, which causes individual variations to play a greater part than if we had a larger number from which to make our average.

TABLE XXIV.—PERCENTAGE OF WATER NORMALLY PASSED IN THE FÆCES ON A PURE MEAT DIET

Number of cases.	Highest per cent.	Lowest per cent.	Average per cent.
6	80·97	68·59	74·26

Quantity of Water in the Fæces on a Meat Diet.—In the preliminary discussion on the absorption of water from the intestine, we showed that the quantity of residue in the diet had a considerable effect on the stimulation of the large intestine, and that resulting stagnation of the contents might be produced by the diminished residue, leading to deficient stimulation. A meat diet, yielding as it does, a stool resembling that of the fasting individual, is, therefore, very apt to cause constipation. In the cases we have examined, constipation has sometimes been present, but not always, and this is probably due to the fact that the large quantity of water given with the diet hindered the constipating effect of the small residue.

In the six examples given in Table XXIV., all the cases of constipation have been eliminated, the results including only those in which no constipation or other apparent bowel trouble had arisen. The maximum quantity of water present in the fæces was found to be 80·97 per cent.; considering that the diet given yielded so little residue, this is high, but as there was apparently no intestinal derangement to account for such a large quantity of water in the fæces, we have included it in the list. The percentage of water found in the other cases was 68·86 per cent., 78·43 per cent., 75·95 per cent., 72·76 per cent. and—the lowest—68·59 per cent., making an average for the six cases of 74·26 per cent. It is thus seen that, on a pure meat diet, there is a distinct tendency to a small quantity of water being eliminated in the fæces, and this is all the more marked when we consider that we have included one case with a particularly high excretion of water. We may, therefore, say that the average amount of water excreted in the fæces tends to be less on a meat diet than on any of the other diets which we employ for the observation of diseases of the bowels.

CHAPTER XVIII

CHEMICAL EXAMINATION OF FÆCES (*continued*)—NITROGEN, ALBUMEN, ALBUMENOSE, PEPTONE, AND MUCUS

Our knowledge of the total nitrogen in the fæces is very complete since Voit's School at Munich made its numerous observations in general metabolism, and V. Noorden applied the same methods to metabolism in disease. The value, however, of the estimation of the total nitrogen in the fæces, in the diagnosis of intestinal diseases, has not been found to be so great as was at first hoped. It is possible that want of sufficient accuracy in comparing results on different diets has crippled the use of the knowledge in diagnosis, and that with extended knowledge we shall find it of real value.

Method of Estimating the Total Quantity of Nitrogen in the Fæces.—Kjeldahl's method for estimating the nitrogen in the fæces is the one most usually employed, and as it yields very good results, it seems to be all that is required.

A weighed quantity of fresh fæces can be employed in estimating the quantity of nitrogen in the fæces by Kjeldahl's method, although in practice we prefer to use a weighed quantity of dried fæces.

The daily quantity of fæces is thoroughly mixed, or in the case of an analysis of a period being carried out, the total three to five days fæces are thoroughly mixed, so that one obtains a fair average specimen. In practice, we generally prefer to make a daily analysis, in order to avoid the danger of losing any nitrogen from the fæces on standing. The weighed quantity of fæces is placed in a capsule, and one-tenth normal sulphuric acid solution poured over it in the proportion of 15 to 20 c.c. to each hundred grams of moist fæces; this is to prevent any loss of ammonia in the process of drying. The capsule is then placed over a water-bath and, with frequent stirring, is allowed to dry, until the fæces are fairly hard. The capsule is then removed, placed in a hot-air oven at 60° C. for two hours, and cooled over sulphuric acid in a dessicator, as in the method for estimating the total quantity of water in the fæces. The contents of the capsule, when cool, are transferred by means of a spatula into a mortar, and ground until all visible lumps have disappeared, and a fine powder remains.

One gram of the powder is placed in a Kjeldahl's destruction flask with 25 c.c. of strong sulphuric acid and one gram of sodium pyrophosphate added to hasten oxydation. The flask is allowed to stand for a few hours (if immediately heated, the contents are apt to foam), and then heated over a Bunsen burner; it is necessary to have the flask placed well on its side, and it is of great assistance to have a small conical glass stopper (Fig. 1), which will arrest any of the boiling sulphuric acid which may spit, and allow it to flow back into the flask. The heating must at first be gentle, and a full power of gas used later, otherwise, there will be too much foaming. The contents of the flask, having been heated till they become perfectly colourless, are allowed to cool. The rationale of the process is the conversion of all the nitrogen present in the fæces into ammonium sulphate, and the destruction of all the organic matter by oxydation.


FIG. 1.

The cold contents of the flask are carefully washed, rinsing three or four times with about 600 c.c. of water, into a large distillation flask.[1] Some granules of zinc are added to prevent much bumping when distillation is carried on, and a strong solution of sodium hydrate added until the contents of the distillation flask are alkaline. The sodium hydrate will, by this method, liberate any ammonia from the ammonium sulphate, and it is only left to collect the ammonia by distilling. The distillation flask is connected so that the liberated ammonia can be distilled over into a measured quantity of deci-normal solution of sulphuric acid. The distillation is carried on until all the ammonia which is present in the distillation flask has been driven over into the one-tenth normal sulphuric acid, and has formed there ammonium sulphate. The measured quantity of sulphuric acid is now titrated with deci-normal sodium hydrate solution, using

[1] Flasks can now be obtained which do for both destruction and distillation.

neutral litmus as an indicator, until one gets a neutral reaction. The quantity of deci-normal sodium hydrate solution required to neutralise the measured quantity of deci-normal sulphuric acid having been subtracted from the original amount, the remainder will give the quantity of sulphuric acid which has been neutralised by the ammonia distilled over, and the calculation of total nitrogen is easily made.

Quantity of Nitrogen in the Normal Fæces.—Formerly it was considered that the nitrogen found in the stools was the remains of undigested proteid, but it is now generally

TABLE XXV.—DAILY EXCRETION OF NITROGEN IN THE FÆCES IN FASTING [1]

Cetti	0·316 grams
Breithaupt	0·116 ,,
Obstruction of the Œsophagus . .	0·446 ,,
First fasting lunatic	0·223 ,,
Second fasting lunatic	0·17 ,,
Average	0·254 grams nitrogen

recognised that the amount of nitrogen left over from digestion, in cases where the food is well prepared and easily assimilated, does not play the only *rôle*; we have also to deal with the nitrogen from the human body itself. Epithelial layers of mucous membrane are being continually shed, and these, together with the mucus and intestinal secretion, create a certain amount of nitrogen residue. In addition to this, we have the bile and pancreatic secretions thrown into the intestine, and these nitrogenous constituents, when not absorbed, add their quantum. The numerous bacteria normally present in the intestine also yield no inconsiderable quantity of nitrogen; some of this nitrogen, being due to the breaking-up of proteid by the bacteria in the intestine, yields nitrogenous residue as well as a certain amount of indol and skatol. And a not inconsiderable quantity of nitrogen is normally due to the bacteria present in the intestines themselves. In fact, Schmidt and Strasburger [2] consider that, on a diet yielding only a small residue, the quantity of nitrogen which may be put down as derived from bacteria is no less than ¼ to ½ of the total nitrogen present in the stools.

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 119.
[2] *Ibid.* p. 120

Our knowledge of the amount of nitrogen derived from the intestines themselves in human beings has, of late years, been greatly amplified, thanks to the observations of Fr. Müller on the fasting individuals, Cetti and Breithaupt.

In Table XXV. one sees that there is a considerable quantity of nitrogen daily eliminated in fasting individuals ; the enormous individual variations in the quantity of nitrogen excreted are also very clearly brought out, so that one must remember, in calculating the quantity of nitrogen in the fæces, to take into account individual variations. The latter are even greater in metabolism experiments, for it is found that the same individual on the same diet during different periods excretes varying quantities of nitrogen. These individual variations, and the variations in the same individual from time to time, render the results obtained by analysis, as to the quantity of nitrogen in the fæces, difficult to deal with.[1] The way the varying quantity of uric acid in the urine is known to fluctuate is analogous to the nitrogen fluctuation found amongst individuals in the fæces.

The quantity of nitrogen shown in Table XXV. only holds good in absolute fasting, for it has been shown by Rieder[2] in three experiments in which he gave nitrogen-free diets, that no less than 0·73 grams of nitrogen were excreted in the fæces per diem. The fact that the quantity of nitrogen excreted by the alimentary canal is larger when food is taken than in fasting, has been shown by several observers, as also the fact that progressive increase in the quantity of non-nitrogenous diet causes a progressive increase in the quantity of nitrogen excreted in the fæces. This is merely what one would expect when one considers that the digestive secretions would be greatly increased by taking a non-nitrogenous diet, compared with the secretions in a fasting individual. The greater the quantity of the non-nitrogenous diet, the greater the quantity of secretion required for its digestion, and, therefore, the greater the quantity of nitrogen left in the residue.

Having shown that a certain quantity of the nitrogen present in the stools is undoubtedly derived from the alimentary canal itself in fasting or on a nitrogen free diet—the quantity varying according to whether digestive secretions are required or

[1] V. Noorden, *Lehrbuch der Pathologie des Stoffwechsels*, Berlin, 1893, p. 39.
[2] *Zeitschr. f. Biologie*, vol. xx. 1884, p. 378.

not—we now go on to see what influence diet has on the nitrogenous residue. It has been clearly shown by experiments that when food is properly prepared, so that it yields only a very small residue, and requires a minimum amount of digestive juice for its absorption, the quantity of nitrogen eliminated is small. In human beings, one always finds on a meat diet (which is the best absorbed of all diets), some undigested muscular fibres in the stools. Rubner[1] showed that on a pure meat diet, 1·12 to 1·2 grams of nitrogen were excreted per diem.

When a diet contains a good deal of residue, more especially cellulose, the quantity of nitrogen is naturally very much increased.

TABLE XXVI.—NITROGEN IN DIET YIELDING RESIDUE[2]

Food.	Daily excretion of nitrogen.	Percentage of nitrogen in dried fæces.	Author.
Potatoes (3078 grams) . .	3·69 grams	3.93	Rubner
Black bread (1360 grams) .	4·26 ,,	3·68	,,
Peas (600 grams) . . .	3·57 ,,	7·35	,,
Carrots (5133 grams) . .	2·52 ,,	3·01	,,
Savoy cabbage (3831 grams) .	2·4 ,,	3·39	,,
Generous Vegetarian Diet .	3·46 ,,	—	Voit
,, ,, ,, .	4·01 ,,	—	Rumpf and Schumm

In Table XXVI. we see that the quantity of nitrogen daily excreted in the fæces on diets which contained a certain amount of cellulose—and, therefore, greatly increased residue—is quite considerable. In fact, the quantities are, as will be found later on, above those observed on our ordinary test meals.

It would seem that the larger the quantity of nitrogen taken in the diet, the less the proportion found in the fæces, so that an increased quantity of nitrogen in the diet would appear to aid digestion. As a matter of fact, this is not really the case; the digestion is not improved, but the total quantity of nitrogen excreted from the alimentary canal being falsely considered as the nitrogen given in the proteids (whereas only a given

1 *Zeitschr. f. Biologie.*, vol. xv. 1879, p. 159.

2 Schmidt and Strasburger, *Die Fæces des Menschen*, p. 122.

quantity is taken in the diet), makes it appear too high; while, if one is giving such a diet as meat, where nearly all the proteid is absorbed, the increased quantity of nitrogen taken in the food yields a relatively smaller quantity of nitrogen in the fæces.

TABLE XXVII.—INFLUENCE OF INCREASED QUANTITY OF DIET ON THE NITROGEN IN THE FÆCES[1]

Diet.	Daily excretion of nitrogen.
Meat (884 grams)	1·2
,, (1435 ,,)	1·12
White bread (689 grams)	1·95
,, (1327 ,,)	2·44
Peas (600 grams)	3·57
,, (960 ,,)	9·09

On the other hand, when a diet yielding more residue is taken, such as a diet of white bread or peas, the quantity of nitrogen excreted in the fæces increases with the quantity taken in the diet, as shown in Table XXVII. (Rubner)

On diets relatively free from residue, the quantity of nitrogen found in the fæces is very small, as shown by Table XXVIII.

TABLE XXVIII.—QUANTITY OF NITROGEN IN THE FÆCES ON RESIDUE FREE DIETS[2]

Food.	Daily excretion of nitrogen.	Percentage of nitrogen in dried fæces.
Macaroni (695 grams) . .	1·86 grams	6·88
White bread (689 grams) . .	1·95 ,,	8·30
Rice (638 grams) . . .	2·13 ,,	7·85
Maize (750 grams) . . .	2·27 ,,	4·6

The quantity of nitrogen present in the fæces is seen to be influenced by the amount of residue left in the fæces, together with the different kinds of diets given, and still further, by individual variations.

It is now necessary for us to consider the quantity of nitrogen present in the fæces when individuals are on one or other of the four diets which we are in the habit of using for the investigation of intestinal disease. In all the cases, the numbers given are

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 123.
[2] *Ibid.* p. 122.

the result of a series of analyses extending over a period of at least three, and generally five days, so that although the number of cases investigated is not great, the results may be considered sufficient for the deduction of general conclusions.

Quantity of Nitrogen in the Fæces on a Milk Diet.—In breast-fed children, less nitrogen is excreted in the fæces than in children fed on cows' milk. Biedert [1] made calculations from a large number of cases, and found in breast-fed children 0·15 grams of nitrogen in the fæces, and in children fed on cows' milk, 0·41 grams of nitrogen in the fæces.

In adults, Schmidt and Strasburger considered that the quantity of nitrogen present in the fæces on a milk diet was about 1·11 grams per diem, but this is a larger quantity than we have found in the cases which have come under our notice.

TABLE XXIX.—QUANTITY OF NITROGEN IN THE FÆCES AND ABSORPTION OF THE SAME ON A MILK DIET

Milk in pints.	Number of cases.	Highest.		Lowest.		Average.	
		Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.
4	6	1·17	95·37	0·63	91·39	0·84	93·82
4½	5	1·20	96·53	0·53	92·16	0·76	95·03
5	2	1·20	94·59	0·92	92·94	1·06	93·76

In Table XXIX. it is seen that when four pints of milk were given daily, the largest quantity of nitrogen excreted per diem was 1·17 grams, and the lowest quantity, 0·63 grams, the cases giving an average of 0·84 grams per diem. If one calculates the quantity of nitrogen given in the food, and subtracts from that the quantity of nitrogen found in the fæces, one obtains a general idea as to the amount of nitrogen absorbed, although, as has already been shown in the general discussion of nitrogen in the fæces, a considerable quantity of the nitrogen is due to the residue of the digestive secretions, epithelial cells, and bacteria, &c., so that absorption calculated by this method is not absolutely correct. As at present we have no means of estimating the quantity of nitrogen eliminated by the human

[1] *Die Kinderernährung im Saüglingsalter*, &c. iv. *Aufl.*, Stuttgart, F. Enke, 1900, p. 59.

being himself, it is essential in these calculations to take for granted that all the nitrogen present in the fæces represents the nitrogen which has not been made use of by the organism. It is seen that in these cases the highest absorption of nitrogen was 95·37 per cent., and the lowest 91·39 per cent., so that the average absorption of proteid in the six cases was 93·82 per cent.

Five cases of individuals who were taking 4½ pints of milk per diem were investigated, and it was found that the maximum quantity of nitrogen present in the fæces was 1·20 grams, and the minimum quantity, 0·53 grams, making an average of 0·76 grams of nitrogen excreted per diem. On making a calculation of the absorption on this diet, it was found that the highest absorption was 96·53 per cent., and the lowest, 92·16 per cent., giving an average absorption in the five cases of 95·03 per cent.

TABLE XXX.—QUANTITY OF NITROGEN IN THE FÆCES AND ABSORPTION OF THE SAME ON A SCHMIDT'S DIET

Number of cases.	Highest.		Lowest.		Average.	
	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.
11	1·90	97·77	0·43	89·94	0·88	95·29

On increasing the diet to five pints of milk per diem, only two cases were investigated. The highest quantity of nitrogen excreted was found to be 1·20 grams, and the lowest, 0·92 grams, giving an average of 1·06 grams per diem. The absorption in these two cases was 94·59 and 92·94 per cent. respectively, giving an average of 93·76 per cent.

We see, therefore, that on a milk diet the quantity of nitrogen present in the fæces is considerably less than the results obtained by Schmidt and Strasburger on the same diet.

The absorption of nitrogen on a milk diet seems to vary between 94 and 95 per cent., which is a very good absorption, especially when one remembers that most of the nitrogen present, as previously mentioned, is due to that derived from the mucous membrane, digestive secretions, &c., thus masking the real absorption of the nitrogen taken in the diet.

Quantity of Nitrogen in the Fæces on Schmidt's Diet.—Eleven cases, in whom there was no sign of gastro-intestinal disturbance, were investigated on a Schmidt's diet.

In Table XXX. it is seen that the highest quantity of nitrogen eliminated in the fæces was 1·90 grams per diem, and the lowest quantity 0·43 grams per diem, giving an average of 0·88 grams per diem. It is thus seen that the average quantity of nitrogen present in the fæces on Schmidt's diet is slightly larger than that found on a milk diet, except when large quantities, such as five pints per diem of milk, were taken.

The highest absorption of nitrogen on this diet was 97·77 per cent., and the lowest 89·94 per cent., the cases giving an average of 95·29 per cent. This is higher than any of the absorptions on the milk diet, and is explained by the fact that the quantity of nitrogen eliminated by the bowel is masked by the increased quantity of nitrogen in the food.

Quantity of Nitrogen in the Fæces on a Mixed Diet.—No less than seventy-five cases taking a mixed diet (without the addition of milk, except in the form of puddings, &c.) were investigated, none of the cases showing signs of any gastro-intestinal derangement.

TABLE XXXI.—QUANTITY OF NITROGEN IN THE FÆCES AND ABSORPTION OF THE SAME ON A MIXED DIET

Number of cases.	Highest.		Lowest.		Average.	
	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.
75	1·55	97·07	0·30	90·12	0·97	93·46

In Table XXXI. it is seen that the highest excretion of nitrogen was 1·55 grams, and the lowest 0·30 grams, the cases yielding an average of 0·97 grams of nitrogen in the fæces per diem. It is seen that the quantity of nitrogen on this diet is considerably larger than that found on either the milk or Schmidt's diet, and this is explained by the increased amount of residue, especially the cellulose residue from the cabbage in the diet.

The highest absorption on a mixed diet was seen to be 97·0. per cent., and the lowest 90·12 per cent., the average of the cases being 93·46 per cent.; these amounts very closely resemble those found on a milk diet, and are considerably less than those obtained with Schmidt's diet.

Quantity of Nitrogen in the Fæces on a Mixed Diet + Increasing Quantities of Milk.—The effect on the nitrogen in the fæces of adding increasing quantities of milk to a mixed diet, is brought out in the following table:

TABLE XXXII.—QUANTITY OF NITROGEN IN THE FÆCES AND THE ABSORPTION OF THE SAME ON A MIXED DIET + INCREASING QUANTITIES OF MILK

Milk in pints.	Number of cases.	Highest.		Lowest.		Average.	
		Nitrogen in grams	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.
1½	26	2·00	97·34	0·57	90·10	1·11	93·84
2	21	1·60	97·55	0·68	93·13	0·94	94·99
2½	10	2·14	96·66	0·85	93·41	1·30	94·60
3	5	2·39	97·26	0·64	93·23	1·44	94·71

It is seen that when 1½ pints of milk daily were added to the diet of twenty-six cases, who showed no sign of intestinal trouble, the highest quantity of nitrogen excreted in the fæces was 2·00 grams, and the lowest 0·57 grams, the cases yielding an average of 1·11 grams per diem. This average is greater than that found in any of the previous diets, and the range between the lowest and the highest figures is also considerably wider than noted in the other diets, being due to individual variations.

The absorption in these twenty-six cases varied from a maximum of 97·34 per cent. to a minimum of 90·10 per cent., the cases giving an average of 93·84 per cent.

On a mixed diet to which two pints of milk were added per diem, twenty-one cases were investigated. The highest quantity of nitrogen was seen to be 1·60 grams, and the lowest 0·68 grams, the cases yielding an average of 0·94 grams of nitrogen excreted per diem in the fæces. It will be noticed that when two pints of milk were added to the diet, the fluctuations were not so great as with 1½ pints of milk, and the average quantity of nitrogen in the fæces was also not quite so high.

The absorption of nitrogen, when two pints of milk were added to the mixed diet, is seen to vary from 97·55 per cent. to 93·13 per cent., the cases averaging 94·99 per cent. per diem.

On a mixed diet when 2½ pints of milk were added, ten cases were investigated. The maximum excretion of nitrogen was found to be 2·14 grams, and the minimum excretion 0·85 grams, the average of the cases being no less than 1·30 grams of nitrogen excreted per diem in the stools. Here we have a larger quantity of total nitrogen in the fæces than in either of the previous diets.

The absorption in these ten cases on a mixed diet with two pints of milk added daily, varied from 96·66 per cent. to 93·41 per cent., the average proteid absorption in the cases being 94·60 per cent. in the twenty-four hours.

On a mixed diet when three pints of milk were taken daily, we only have the analyses of five cases. The highest quantity of nitrogen found in the fæces was 2·39 grams, and the lowest 0·64 grams, the cases giving an average of 1·44 grams of nitrogen in the fæces per diem, this being a greater quantity than had been seen in any of the diets which we have just discussed.

The highest absorption was 97·26 per cent. and the lowest 93·23 per cent., the cases yielding an average of 94·71 per cent.

On glancing over these cases on a mixed diet with the addition of milk, one sees a distinct tendency to increase in the quantity of nitrogen corresponding with the increase in the quantity of milk given. In the case of two pints of milk being given, it is seen that there was no increase in the quantity of nitrogen excreted, but individual variations have to be considered, and one must draw general conclusions from the results as a whole, regarding the non-increase of nitrogen on two pints of milk as an exception.

The absorption of nitrogen tends also to increase with increasing quantities of milk in the diet.

Quantity of Nitrogen in the Fæces on a Meat Diet.—Table XXXIII. gives the results in five cases which were investigated on a pure meat diet.

It is seen that the maximum quantity of nitrogen excreted was 0·79 grams, the minimum being very low, only 0·26 grams, and the average 0·52 grams, while the average quantity of nitrogen in the fæces in fasting has already been shown to be 0·25 grams in the twenty-four hours.

The absorption of nitrogen on a purely meat diet varied from

97·16 per cent. to 91·48 per cent., the average of the cases being 95·32 per cent.

Since a meat diet yields very little residue, and is even better absorbed than a milk diet, there is a tendency for the quantity of nitrogen in the fæces to be extremely low; at the same time,

TABLE XXXIII.—QUANTITY OF NITROGEN IN THE FÆCES AND ABSORPTION OF THE SAME ON A PURE MEAT DIET

Number of cases.	Highest.		Lowest.		Average.	
	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.	Nitrogen in grams.	Absorbed per cent.
5	0·79	97·16	0·26	91·48	0·52	95·32

owing to the large quantity of nitrogen relatively present in the diet, the absorption of nitrogen is very good.

ALBUMEN, ALBUMENOSES, AND PEPTONE

The tests for albumen, albumenoses, and peptone, can be roughly considered together.

Test for Albumen.—Fresh fæces should be well mixed with water, and then rubbed up in a mortar, filtered through a folded filter paper, and the filtrate tested for albumen. If the fæces are alkaline, one also gets, in solution, casein and mucus, which can be prevented by previously using dilute acetic acid.

(1) To the bottom of the filtrate in a test-tube a layer of cold nitric acid is run in, when a white precipitate forms at the junction of the liquids if albumen is present.

(2) The upper layers of the watery extract of the fæces are heated in a test-tube, when a precipitate will form. Two to three drops of dilute acetic acid can be added, and, if albumen is present, the precipitate remains, and sometimes increases in quantity.

Test for Albumenoses and Peptone: Hofmeister's Method.[1]—To well-rubbed-up fæces 0·1 volumes of concentrated hydrochloric acid are added; then phosphorstungstic acid and hydrochloric acid are alternately added until no more

[1] Hoppe-Seyler's *Chemische Analyse*. Edited by Thierfidler, 7th edition, p. 454.

precipitate is formed; after gently heating, the thick precipitate is collected on a filter-paper, which is well washed with water, and dissolved in sodium hydrate solution. The resulting deep blue liquid is heated over a flame on a gauze until it turns a dirty yellow; some of the fluid is then poured into a test-tube, cooled, and tested for the biuret reaction, the propeptone or albumose giving a violet or reddish colour.

Presence of Albumen.—In healthy children there ought to be no albumen present in the fæces, but when there is any enteritis or summer diarrhœa, albumen is always found to be present in the fæces.

In adults on ordinary diets albumen is not to be found in the fæces under normal conditions. It is difficult to distinguish between unabsorbed albumen and that which is derived from the alimentary tract itself. The albumen present in cases of simple diarrhœa or jaundice seems to be due to the unabsorbed residue of the food. On the other hand, the albumen found in the stools in cases of cholera may be derived from the alimentary tract itself; also when mucus, blood, or pus, are present in the motion, albumen may be due to these substances. One has to remember that the large intestine will absorb considerable quantities of albumen, and, therefore, when albumen appears in the fæces, there must be great disturbance of the alimentary tract. In pathological conditions, such as enteritis and colitis, one finds a very marked quantity of albumen. In chronic mucoid conditions of the bowel, there is generally a slight albumen reaction. In chronic constipation, as a rule, one finds a mere trace of albumen, or it is absent. In all cases of diarrhœa, from whatever cause, it would appear that there is a marked reaction for albumen in the fæces.

MUCUS

Mucus, as glycero-proteid which can be broken up into proteid and carbohydrates, is distinguished from the neucleo-proteids or nuclein by the latter containing phosphorus. Small particles of mucus can be easily recognised in the fæces, and can be picked out with forceps, and shaken in a test-tube with 2½ per cent. alcoholic sublimate solution, so as to break up the larger particles; if necessary, a glass rod may be used to disintegrate any large flocculi. It is then allowed to sediment, and is washed with distilled water, after which a few drops of Ehrlich Brondi tri-acid solution[1] are poured over it. With this reagent, the flocculi of mucus, if not containing fat and epithelial cells, are stained green or blue-green, all other tissue substances except nuclein being red.

Chemical Test for Mucus: *Hoppe-Seyler's Method.*—Fresh fæces are well mixed with lime-water, and the lime-water extract precipitated with acetic acid. The mucus thus precipitated must be free from phosphorus, and, on heating with 7·5 per cent. hydrochloric acid, will yield a reducing substance. The reducing substance is tested by neutralising the filtrate with sodium hydrate, and boiling with a few drops of copper sulphate solution, when a reduction of the copper is obtained.

Ordinary mucus in the fæces is often so much mixed up with fat and epithelial cells that it can only, with great difficulty, be dissolved in lime-water. This Hoppe-Seyler method has the disadvantage that it also precipitates nuclein and nucleo-proteids, and in order to make sure that one is dealing with mucus, it is necessary to ascertain that the precipitate contains no phosphorus, and to see that one is able to obtain a reducing substance from it after boiling with acid. As a general rule, mucus can be recognised macroscopically and microscopically with sufficient accuracy to justify one in dispensing with chemical analysis.

The mucus found in membranous enteritis is always so mixed with epithelial cells and fat, that it is insoluble in lime-water, and only soluble in strong sodium hydrate solution.

Presence of Mucus.—The normal fæces contain no mucus except in very early childhood. In adults, a small quantity of mucus may coat a solid motion even in health, and in constipation, one always finds a certain amount of slimy mucus between the lumps or scybala.

[1] Ehrlich Brondi three-coloured mixture consists of saturated solution of Orange G. acid fuchsin and methyl green, as follows:

Saturated solution of Orange G.	24–27 c.c.
Acid fuchsin	16–33 c.c.
Methyl green	35 c.c.
Water	60 c.c.
Absolute alcohol	40 c.c.
Glycerine	20 c.c.

(The mixture should be allowed to stand for one or two weeks before using.)

The fate of the mucus secreted by the various portions of the gastro-intestinal tract can be briefly summarised as follows:

Mucus derived from the stomach is never present in the stools, owing to its being easily digested.

Mucus derived from the small intestine is only present in the fæces when increased peristalsis is hastening it along the large intestine. It is recognised as coming from the small intestine by the fact that it is usually coloured with bile, and more or less intimately mixed with the fæces.

Mucus which is found to be intimately mixed with the fæces, and is not coloured by bile, is derived from the upper part of the large intestine.

Mucus found between the scybala or coating rolls of fæces is derived from the lower part of the large intestine, probably in most cases from the rectum.

If, on examination, the mucus present in the stools is found to be mixed with epithelial cells, it indicates catarrh of the bowel.

The mucus of membranous enteritis is nearly always found to have mixed with it numerous epithelial cells and fat drops. It would appear that the mucus accompanying acute catarrh is probably due to hypersecretion from a secretory neurosis, and not to true inflammation of the bowel.

CHAPTER XIX

CHEMICAL EXAMINATION OF FÆCES (*continued*)—FAT

THE qualitative reaction of fat in the fæces is of very little importance, since, in all cases, a certain quantity of fat will be found in the stools.

The total ether extract is, as a rule, taken to represent the fat in the estimation of its quantity in the fæces, and the thorough isolation of the fatty acids, soaps, neutral fats, and cholesterin has not so far been found to repay the trouble entailed.

Quantitative Estimation of Fat.—A weighed quantity of finely powdered dry fæces, after having been dried down with sulphuric acid, as in the estimation of total nitrogen, or with the addition of 1 per cent. of hydrochloric acid, is taken for the estimation of the fat. It is necessary to dry down the fæces with an acid so as to split up any of the soaps present, and render them soluble in ether. The powder is placed in a fat-free filter-paper in a Soxhlet apparatus, connected with a reflux cooler, and extracted with ether until no further fat is obtained on extraction. The ether extract, after being dried, is dissolved in water-free ether, and filtered into a weighed Erlenmeyer, the ether evaporated off, and, when dried, weighed. The increased weight thus obtained yields the total ether extract, and for all purposes of analysis is sufficiently accurate to be called fat.

Chemical Analysis to Estimate the Quantity of Neutral Fat, Fatty Acids, and Soaps.[1]—Some fæces, after being well mixed, are dried at 90° C., placed in a Soxhlet apparatus, and extracted with ether until all the soluble matter is dissolved. The ether mixture is then dried and redissolved in absolute ether, sp. gr. 0·720, and filtered

1 Vaughan Harley, "On the Breaking-up of Fat in the Alimentary Canal under Normal Circumstances and in the Absence of the Pancreas."—*Proc. Roy. Soc.*, vol. lxi.

through a fat-free filter-paper into a weighed vessel, in which it is dried and afterwards weighed.

The ether residue thus obtained is then treated with a watery solution of sodium carbonate, which converts free fatty acids into soaps; after again drying, the neutral fat, cholesterin, &c., are extracted from this by means of ether filtered through a fat-free filter-paper and weighed. The difference between this and the first weighing is taken to equal the quantity of free fatty acids present.

The neutral fat present in the last ether extract is then

TABLE XXXIV.—QUANTITY OF FAT PRESENT IN THE FÆCES IN FASTING INDIVIDUALS[1]

	Percentage of fat in dried fæces.	Total fat per diem.	Neutral fats and cholesterin.	Fat acids.	Soaps.
Cetti . . .	35·46	1·21 grams	55·02 %	37·65 %	7·33 %
Breithaupt . .	28·42	0·57 „	47·0 %	41·5 %	11·5 %
Case of obstruction of œsophagus	26·3	1·14 „			

saponified by the addition of alcoholic sodium hydrate solution and evaporated to dryness, when it is again extracted with ether. It is necessary to repeat this saponification with alcoholic sodium hydrate solution until all the neutral fats are removed. The ether extract left will contain cholesterin.

The original substance which was extracted with ether is treated with dilute hydrochloric acid in order to liberate from the soaps any fatty acids which may be present. It is then dried at 90° C., and when completely dry, again extracted with ether. The quantity of ether extract which is then obtained represents the fatty acids present in the form of soaps.

Fat in Normal Fæces.—In discussing the nitrogen in the normal fæces, we showed that a certain quantity of the nitrogen in the stools has nothing to do with the diet taken, and, in the same way, we find in the normal fæces that a certain amount of fat is derived from the excretions of the alimentary canal itself. This fat represents not only the quantity of fat

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 155.

contained in the digestive juices, but also that derived from the mucous membrane in the breaking-up of the epithelial cells which are continually thrown off from the intestinal wall.

Fr. Müller carried out a series of analyses of the quantity of fat in the fæces of fasting individuals, similar to those which have been already described in the case of nitrogen.

It is seen in Table XXXIV. that the average excretion of fat in a fasting individual is no less than 0·79 grams per diem. It is also seen that the daily excretion of fat varies very considerably in different individuals, the maximum being 1·21 grams, and the minimum 0·57 grams in the twenty-four hours. We

TABLE XXXV.—INFLUENCE OF MELTING-POINTS OF FATS ON THE PERCENTAGE ABSORPTION [1]

Kind of fat.	Melting-point ° C.	Percentage excreted.
Stearin	60	91–86
Mixture of stearin and almond oil	55	10·6
Mutton suet	52	9·15
Mutton suet	49	7·4
Bacon fat	43	2·58
Pork fat	34	2·5
Goose fat	25	2·5
Olive oil	Liquid	2·3

thus see that there is great individual variation in the quantity of fat daily excreted from the alimentary canal in fasting individuals, and in all analyses on the quantity of fat in the fæces, we must bear in mind these individual variations, just as we had to do in the case of nitrogen.

Kobert and Koch [2] examined a patient with an artificial anus at the commencement of the ascending colon, and they were able to wash out daily from the large intestine 0·97 grams of dry substance, which contained from 6·8 to 9·3 per cent. of fat. This would yield about 0·09 grams of fat per diem excreted from the large intestine itself, so that when we compare the quantity of fat in a fasting individual with the quantity of fat which is evidently excreted from the large intestine, we see

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 156.
[2] *Deutsche Med. Wochenschr.*, 1894, No. 47.

that the greater portion of the fat must be excreted by the small intestine or in the bile and pancreatic juice.[1]

The quantity of fat excreted by the alimentary canal also appears to be influenced by the diet taken, irrespective of the diet containing any fat, for Rubner found on a fat-free diet consisting of bread and dumpling, no less than 3·1 to 6·5 grams of fat daily excreted in the fæces.

Influence of Melting-points of Different Fats on Absorption.—The fats taken in the diet vary very much as regards their melting-points, and the facility of absorption is thereby very considerably influenced.

It is seen in Table XXXV. that the lower the melting-point, the better the absorption of fat. It has also been found that the better the fat is emulsified in the process of digestion, the better it is absorbed; so that butter and other pure fats are more easily digested than, for instance, mutton suet. There would appear to be individual variations in the assimilation of fat, since Hultgren and Landergren[2] found, on a similar diet, individual differences in the quantity of fat absorbed. On margarine, from 95·5 to 92·3 per cent. of fat was absorbed, while when butter was given, 97.3 to 93·7 per cent. was absorbed.

The quantity of fat present in the food has an influence on the quantity absorbed. In a diet containing a small quantity of fat, it is not at all uncommon to find more fat in the fæces than had been taken in the food. It is easily understood that part of this large quantity of fat found in the fæces is derived from the excretions of the body itself.

Malfatti[3] found in an individual on a diet of peas, which contained only 4·06 grams of fat, that he was able to recover 4·51 grams in the fæces in twenty-four hours. V. Hösslin[4] on taking 1·2 grams of fat in the food, found that he obtained 1·71 grams of fat in the fæces, and in another case when 3·6 grams of fat were given in the diet, no less than 3·75 grams of fat were found in the fæces.

1 The composition of the excretion of the loop of the large intestine is given in "The Influence of Removal of the Large Intestine and Increasing Quantities of Fat in the Diet on General Metabolism in Dogs."—Vaughan Harley, *Proc. Roy. Soc.*, vol. lxiv.

2 *Pflüger Archives*, vol. lx.

3 Quoted by J. König, *Chemie der menschl. Nahrungs u. Genussmittel*, 1889, iii., aufl. i. p. 36 ff.

4 *Virchow's Archiv*, vol. lxxxix., 1882, p. 95.

Increasing quantities of fat in the diet are shown to give relatively better absorptions of fat. V. Noorden[1] found that when he gave 4·2 grams of fat in the diet, 57·1 per cent. of it appeared in the fæces, while when he increased the fat in the diet to 42·2 grams, the quantity of fat in the fæces was 10·9 per cent., and on still further increasing the fat in the diet to 80·2 grams, only 6·36 per cent. of the fat was lost.

It will be seen from these results that it is impossible when a small quantity of fat is given in the diet, to come to any conclusions as to its absorption ; at the same time, when an ordinary diet is taken, containing a fair amount of fat, we may consider that the excretion from the human body itself remains more or less constant, and we are, therefore, justified in making a calculation of the absorption by estimating the quantity of fat found in the fæces.

Rubner considered that the assimilation of fat reached its maximum when 350 grams of fat (butter) were taken in the diet per diem.

We now come to consider the quantity of fat present in the fæces on the various diets which we employ for the examination into intestinal diseases.

Quantity of Fat in the Fæces on a Milk Diet.— Breast-fed children yield from 10 to 20 per cent. of dry substance in the fæces as fat, while the amount on cows' milk is from 14 to 23·8 per cent. The absolute quantity of fat lost in the fæces on cows' milk is greater than that on mother's milk, owing to the larger quantity of fæces. Uffelmann reckoned that 0·8 to 0·9 grams of fat were excreted per diem on cows' milk, as against 0·44 grams on mother's milk.

In adults, the quantity of fat found in the fæces varies with the quantity of milk taken, Schmidt and Strasburger stating that from 97 to 93 per cent. of the fat given in the diet is absorbed, the average being 93·93 per cent. ; the daily quantity of fat excreted in the fæces, according to these observers, is 1·5 to 7·5 grams per diem. It may be roughly stated that on a milk diet in infants, 94·9 to 93 per cent. of the fat given is absorbed, while in adults from 95·6 to 93·4 per cent. of the fat given in the food is absorbed.

[1] *Lehrbuch der Pathologie des Stoffwechsels*, Berlin, 1893.

We will now give the results of some analyses illustrating what we have found on a milk diet.

TABLE XXXVI.—QUANTITY OF FAT IN THE FÆCES AND ABSORPTION PER CENT. ON A MILK DIET

Milk in pints.	Number of cases.	Highest.		Lowest.		Average.	
		Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.
4	6	3·14	98·67	1·12	96·26	2·18	97·40
4½	6	5·40	97·73	1·14	93·23	2·95	95·82
5	2	5·22	95·19	5·05	95·03	5·13	95·11

In Table XXXVI. it is seen that six cases taking four pints of milk per diem were analysed, there being no gastro-intestinal disturbance. The highest quantity of fat in the fæces was 3·14 grams, and the lowest 1·12 grams, the cases yielding an average of 2·18 grams of fat daily excreted in the fæces.

The absorption in these cases on four pints of milk varied from 98·67 per cent. to 96·26 per cent., the average absorption of fat per diem being 97·40 per cent. The absorption of fat is thus better than the absorption of proteid on a milk diet.

Analyses of six cases on 4½ pints of milk per diem show the highest quantity of fat in twenty-four hours to be 5·40 grams, and the lowest 1·14 grams, giving an average of 2·95 grams of fat in the fæces per diem.

The highest absorption on 4½ pints of milk was 97·73 per cent., and th lowest 93·23 per cent., the average absorption of fat per diem being 95·82 per cent.

In two further cases, analyses were carried out, the individuals taking five pints of milk per diem. These cases yielded 5·22 grams and 5·05 grams of fat in the fæces respectively, the average being 5·13 grams.

The absorption in these two individuals taking five pints of milk daily, showed a maximum absorption of 95·19 per cent., the minimum absorption being 95·03 per cent., giving an average of 95·11 per cent. of fat daily absorbed.

On looking through these cases on a milk diet, we see that there is a general tendency to an increase in the quantity of fat in the fæces on increased quantities of milk. This is only what one would expect, as the increased quantity of fat contained in the increased quantity of milk would, in all probability, lead to increased residue. On the other hand we see that with an increased quantity of milk the tendency is for the absorption of fat to decline, so that there is apparently a tendency to decrease in actual absorption with increased quantities of milk, contrary to what one finds when fat is increased in an ordinary mixed diet.

Quantity of Fat in the Fæces on Schmidt's Diet.—On Schmidt's diet, ten cases were examined, none of whom evinced any tendency to intestinal derangement.

TABLE XXXVII.—QUANTITY OF FAT IN THE FÆCES AND ABSORPTION PER CENT. ON SCHMIDT'S DIET

Number of cases.	Highest.		Lowest.		Average.	
	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.
10	6·47	97·55	2·12	94·63	4·26	96·15

In Table XXXVII. the highest quantity of fat in the fæces is seen to be 6·47 grams per diem, and the lowest 2·12 grams, giving an average, in the cases examined, of 4·26 grams of fat excreted in the fæces per diem on Schmidt's diet. The variation in the quantity of fat is very considerable when one takes into consideration the fact that the diets given were exactly the same, and it shows how great individual variations may be.

The absorption of fat in these ten cases on Schmidt's diet showed a maximum of 97·55 per cent., and a minimum of 94.63 per cent., making the average daily absorption of fat 96·15 per

TABLE XXXVIII.—QUANTITY OF FAT IN THE FÆCES AND ABSORPTION PER CENT. ON A MIXED DIET

Number of cases.	Highest.		Lowest.		Average.	
	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.
79	6·07	98·51	1·13	90·19	3·29	95·05

cent. We see that the absorption of fat on Schmidt's diet very closely resembles that found on a milk diet.

Quantity of Fat in the Fæces on a Mixed Diet.—On a mixed diet, in which no milk was given except in the form of puddings, &c., seventy-nine cases were investigated.

In Table XXXVIII. results of the seventy-nine cases are given. The maximum quantity of fat excreted was 6·07 grams, and the minimum 1·13 grams, the cases giving an average of 3·29 grams of fat in the fæces per diem.

The absorption in these seventy-nine cases taking a mixed diet varied from 98·51 to 90·19 per cent., and yielded an average daily absorption of 95·05 per cent. The absorption, therefore on a mixed diet was not so good as the absorption on either Schmidt's or the milk diet.

Quantity of Fat in the Fæces on a Mixed Diet with the Addition of Increasing Quantities of Milk.—The influence on the fat in the fæces of increasing quantities of milk in the diet was investigated in a series of cases, and in Table XXXIX. the highest and lowest results found in the analyses of some sixty-two cases, together with the average absorption obtained on these diets, are given :

TABLE XXXIX.—QUANTITY OF FAT IN THE FÆCES AND ABSORPTION PER CENT. ON A MIXED DIET + INCREASING QUANTITIES OF MILK

Milk in pints.	Number of cases.	Highest.		Lowest.		Average.	
		Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.
1½	26	7·85	98·28	1·96	91·37	3·75	95·62
2	21	6·85	98·43	1·71	91·77	3·35	96·20
2½	10	5·41	98·18	2·39	91·86	4·24	95·47
3	5	5·27	97·64	2·50	95·11	3·75	96·68

It is seen that when 1½ pints of milk were added to the ordinary mixed diet, the highest quantity of fat found in the fæces was 7·85 grams, and the lowest 1·96 grams, the cases giving an average of 3·75 grams of fat in the fæces per diem. It is interesting to notice the very large individual variations in the quantity of fat eliminated on an ordinary mixed diet with the addition of 1½ pints of milk, when there was apparently no intestinal trouble.

The absorption of fat on a mixed diet with 1½ pints of milk varied from 98·28 per cent. to 91·37 per cent., the average of the twenty-six cases being 95·62 per cent.

On a mixed diet to which two pints of milk were added, twenty-one cases were investigated, and showed a maximum of 6·85 grams of fat in the fæces, a minimum of 1·71 grams, and an average daily excretion of 3·35 grams.

The absorption on a mixed diet with the addition of two pints of milk varied from 98·43 per cent. to 91·77 per cent., making an average absorption of 96·20 per cent. per diem.

On a mixed diet to which 2½ pints of milk were added, ten cases were investigated, and these showed a maximum fat excretion of 5·41 grams and a minimum of 2·39 grams, the average daily excretion of fat in the fæces being 4·24 grams.

TABLE XL.—QUANTITY OF FAT IN THE FÆCES AND ABSORPTION PER CENT. ON A PURE MEAT DIET

Number of cases.	Highest.		Lowest.		Average.	
	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.	Fat in grams.	Absorbed per cent.
5	2·43	96·90	0·53	92·40	1·22	94·77

The absorption of fat on a mixed diet with 2½ pints of milk varied from 98·18 per cent. to 91·86 per cent., making an average daily absorption of 95·47 per cent.

On a mixed diet to which three pints of milk were added daily, five cases were analysed, and of these the highest quantity of fat found in the fæces was 5·27 grams, and the lowest 2·50 grams, giving an average of 3·75 grams of fat excretion per diem.

The absorption of fat on the mixed diet when three pints of milk were added varied from 97·64 per cent. to 95·11 per cent., the average daily absorption of fat being 96·68 per cent.

On looking over these results, we notice a tendency for the quantity of fat to be increased in the fæces when increased quantities of milk were given in the diet. At the same time, the increase is not nearly so marked as when the milk was increased, and no other diet taken.

The absorption of fat when increasing quantities of milk were added to a mixed diet seems to be little influenced when one compares the results of analyses given.

Quantity of Fat in the Fæces on a Meat Diet.—In five cases in whom the bowels appeared to be perfectly healthy, analyses were carried out on a pure meat diet, and the results are tabulated in Table XL.

We see that in the five individuals on a pure meat diet, the maximum quantity of fat found in the fæces was 2·43 grams, and the minimum 0·53 grams, the average excretion being 1·22 grams per diem.

The absorption in these five cases on a meat diet varied from 96·90 per cent. to 92·40 per cent., the average daily absorption being 94·77 per cent. This low absorption of fat is due to the small quantity taken in the diet and has already been explained.

CHAPTER XX

CHEMICAL EXAMINATION OF FÆCES (*continued*)—SUGAR AND CARBOHYDRATES

SUGAR can be examined for either with fresh or dry fæces.

Alcoholic Method of Estimating Sugar.—A weighed quantity of either fresh or dried fæces is placed in an Erlenmeyer, and ten volumes of absolute alcohol added; after having been thoroughly mixed and filtered, the residue is washed with alcohol containing a little water. The alcoholic filtrate is evaporated to dryness in a capsule, and the residue dissolved in water. By this means, the albumen and albumoses are removed from the sugar-containing solution. If a quantitative analysis is to be made, it is desirable to allow the fæces to stand in contact with absolute alcohol for at least two or three days with frequent shaking before filtration, so that the proteids may form a more insoluble precipitate with the alcohol. The filtrate can be tested for sugar either by Fehling's solution or by fermentation.

Blauberg's Lead Acetate Method.[1]—Some dried fæces, which have been extracted with ether, so as to render them more or less free from fat, are extracted with Thymol water by heating on a water-bath, filtered, and washed with Thymol water. The filtrate is precipitated with lead acetate or basic acetate of lead. The excess of lead is removed by passing a stream of carbonic acid through it, and the fresh filtrate is tested for sugar.

Either of these methods may be employed, but we have found in practice the alcoholic method to be the more convenient.

Presence of Sugar.—In children fed on milk, a small quantity of sugar is found in the fæces. In children taking the breast, Pusch and Callomon[2] found by means of the fermen-

[1] Quoted by Schmidt and Strasburger, *Die Fæces des Menschen*, p. 172.

[2] *Experimentelle und kritische Studien über Säuglingsfæces*, Berlin, 1897, p. 39.

tation test, a fair quantity of sugar even in cases where there was no marked diarrhœa.

Cohnheim[1] found sugar present in the fæces in individuals suffering from diarrhœa.

Under ordinary circumstances it is found that the fæces contain no sugar. In fact, so far as our experience has gone, we have never recognised any sugar in the fæces, and similar results have been found by Rubner,[2] Uffelmann,[3] &c.

CARBOHYDRATES

Starch is, as a rule, easily recognised in the fæces by the aid of the microscope, especially when a solution of iodine and potassium iodide has been employed, and, for ordinary purposes we have found this ample (*see* p. 113).

Method of Estimating the Carbohydrates in the Fæces.—A weighed quantity of either fresh or dried fæces free, as far as possible, from any mixture of mucus, is placed in a flask to which 2 per cent. solution of hydrochloric acid is added. The flask is connected with a reflux cooler, and heated on a sand-bath for one or two hours. The filtrate, having been neutralised with sodium hydrate, is tested for sugar by Allihn's method.

To about 100 c.c. of filtrate, 60 c.c. of Fehling's solution is added in a small flask, and after covering with a watch-glass, well boiled.

Allihn's glass tubes require to very carefully filled with asbestos, the asbestos having been previously prepared with boiling water and afterwards with alcohol and ether. It is essential in filling the Allihn tube with asbestos to be very careful, otherwise there may be difficulty in the filtration. It is well first to use long pieces of asbestos, carefully packing them with a glass rod, and then washing on to the top of the packed asbestos some finely cut asbestos suspended in water so as to make a fine surface on the top, which will prevent any of the copper oxide from coming through the filter. It is important in stopping these filters to take care not to pack them too tightly, as otherwise there will be great difficulty in filtration.

1 *Vorselungen über allgemeine Pathologie*, 1882, Bd. ii. p. 140.
2 *Zeitschr. f. Biologie*, vol. xv., 1879, p. 130.
3 *Pflüger's Archiv.*, vol. xxix., 1882, p. 356.

The Allihn tube, having been carefully prepared, is dried and weighed. The sugar-containing solution, after being well boiled with Fehling's solution, is then filtered by the aid of a suction pump through the asbestos filter, the flask being well washed with boiling water, and all the copper oxide washed on to the asbestos by means of a glass rod tipped with rubber.

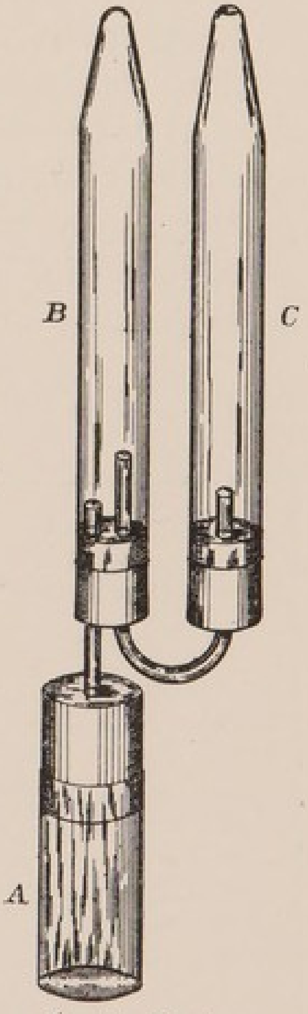
ALLIHN'S TABLE.[1]—QUANTITY OF SUGAR CALCULATED FROM THE WEIGHT OF COPPER OR COPPER OXIDE

Sugar.	Copper.	Copper oxide.	Sugar.	Copper.	Copper oxide.
6.25	18·94	—	36	82·4	92·8
12	32·8	36·8	37	84·4	95·1
13	34·9	39·2	38	86·5	97·4
14	37·0	41·6	39	88·5	99·7
15	39·1	43·9	40	90·5	101·9
16	41·2	46·3	41	92·6	104·2
17	43·3	48·7	42	94·6	106·5
18	45·4	51·0	43	96·6	108·8
19	47·5	53·4	44	98·6	111·1
20	49·6	55·8	45	100·7	113·4
21	51·7	58·1	46	102·7	115·7
22	53·8	60·5	47	104·7	118·0
23	55·9	62·9	48	106·7	120·2
24	58·0	65·2	49	108·8	122·5
25	60·1	67·6	50	110·8	124·8
26	62·1	69·9	51	112·8	127·1
27	64·2	72·2	52	114·9	129·4
28	66·2	74·5	53	116·9	131·7
29	68·2	76·8	54	119·0	134·0
30	70·2	79·1	55	121·0	136·3
31	72·3	81·3	56	123·0	138·6
32	74·3	83·6	57	125·1	140·9
33	76·3	85·9	58	127·1	143·2
34	78·4	88·2	59	129·2	145·5
35	80·4	90·5	60	131·2	147·8

After washing with hot water, alcohol, and ether, the tube is sucked as dry as possible, after which a stream of hydrogen is allowed to pass through it, and while passing through the asbestos, the asbestos part of the tube is heated in a flame to redness. By this means the copper oxide will be reduced to metallic copper. On cooling, the tube is again weighed, and from the quantity of reduced copper found in the tube, the quantity of sugar is calculated by referring to Allihn's table.

1 Schmidt and Strasburger, *Die Fæces des Menschen*, p. 176.

Strasburger prefers to use Volhard-Pflüger's Copper Cyanide Method because, in the above-described method, there may be, besides the collection of copper on the Allihn's filter, some impurities from the filtrate in the fæces collected on the asbestos. Most of these foreign substances, however, would be burnt during the heating of the tube in the flame, as well as which the method of estimating carbohydrates in the fæces by converting them into sugar by boiling with dilute hydrochloric acid is not accurate, because other substances besides carbohydrates, such as mucus, can hardly help being broken up in the process, thus yielding copper reducing substances, and tending to make the results obtained by the method of analysis too high.



$\frac{1}{3}$ *actual size.*

FIG. 2.

Method of Estimating Carbohydrates by Schmidt's Fermentation Tests.—Schmidt[1] has introduced an ingenious method of estimating the amount of fermentation going on in the fæces, thus obtaining a rough idea of the quantity of carbohydrates present in the stool.

About five grams of fæces, or if very fluid, a quantity sufficient to yield about one gram of dry substance, is put into fermentation tube *A* (Fig. 2), and well mixed with water. An indiarubber stopper connected with tube *B* is inserted into the fermentation tube, avoiding any bubbles of gas, tube *B* having been previously filled with water and connected with tube *C* which has a small opening at the top, and contains no water. The apparatus, put together as seen in Fig. 2 is then allowed to stand in an oven at 37° C. for twenty-four hours; the gas formed in the fæces passes up into tube *B* and drives the water over into tube *C*.

If, from a given quantity of starch, a given quantity of gas was developed, this method would be very accurate for the quantitative estimation of carbohydrates in the fæces, but, unfortunately, this is not found to be the case. Schmidt

1 Schmidt and Strasburger, *Die Fæces des Menschen*, p. 178.

considered that by this fermentation method one ought *not* to get normally more than one-quarter of *B* filled with gas from one gram of dried fæces. In employing this method, we have found it essential to use very fresh fæces, otherwise, the process seems to be most inaccurate.

Presence of Carbohydrates.—The presence of starch in the fæces, although of undoubted importance, has not, unfortunately, been investigated by us so thoroughly as the presence of nitrogen and fat, partly because of the difficulty of carrying out the methods with sufficient accuracy to draw definite conclusions, and partly because the micro-chemical reaction has seemed to us to be sufficient for making a diagnosis when the alternative is working with inaccurate methods.

When finely prepared starch is given in the diet, such as white bread made from very finely ground flour, only a very small quantity of carbohydrates, if any, is found in the fæces.

TABLE XLI.—INFLUENCE OF THE FINENESS OF PREPARATION OF THE FOOD[1]

Kind of food.	Carbo-hydrates in the food.	Carbo-hydrates in the fæces.	Author.
Fine white flour . . .	528·8	5·83	Rübner
Medium flour	507·9	13·10	,,
Whole meal	504·5	37·23	,,
Bread made from ground rye .	515·6	45·7	Wicke
Bread made from whole rye .	481·6	61·4	,,
Rice	493	4·0	Rübner
Dumplings	557·5	9·0	,,
Maize	563	18·0	,,
Peas	587·9	41·0	,,

In Table XLI., the influence of fineness of preparation of the carbohydrates on the quantity present in the fæces is well illustrated.

It has been shown by Rübner that when 528·8 grams of white flour were given, only 5·83 grams of carbohydrates were found in the fæces; while, when 481·6 grams of whole rye were given, no less than 61·4 grams of carbohydrates were found in the fæces.

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 181.

The quantity of carbohydrates taken in the diet has also a considerable influence on the quantity found in the fæces.

TABLE XLII.—INFLUENCE OF THE QUANTITY OF CARBOHYDRATES IN THE FOOD[1]

Kind of food.	Carbohydrates in the food.	Carbohydrates in the fæces.	Author.
White bread . .	391·1	6·0	Rübner
,, ,, . .	670·1	5·0	,,
Peas, 600·0 grams . .	357·0	12·9	,,
,, 959·8 ,, . .	587·9	41·0	,,

In Table XLII. it will be seen that, when white bread was given, the quantity of bread made no difference in the quantity of carbohydrates found in the fæces, while, on the other hand, when peas, which are more difficult to digest, were employed, the effect of increasing the carbohydrates in the diet was to cause a very marked increase in the quantity of carbohydrates found in the fæces.

1 Schmidt and Strasburger, *Die Fæces des Menschen*, p. 182.

CHAPTER XXI

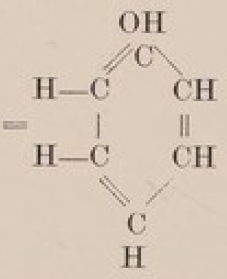
CHEMICAL EXAMINATION OF FÆCES (*continued*)—PHENOL, INDOL, AND SKATOL

THE three substances, phenol, indol, and skatol, which are derived from the breaking-down of the proteids by the action of bacteria in the large intestine, can well be described in a group.

Hoppe-Seyler's Method of Analysis.[1]—The specimen of fæces to be examined is mixed with water until it forms a paste, and, after adding more water, is placed in a distillation flask which is connected with a cooler and heated over a free flame, and distilled to one-third its volume. The distillate (1) will contain free fatty acids, phenol, indol, and skatol. This distillate is mixed with sodium carbonate solution in order to convert the free fatty acids into sodium soaps, and thus render them no longer volatile. After the further addition of water, it is again distilled, and this time phenol, indol, and skatol will come over in the distillate (2).

The distillate (2) is rendered strongly alkaline by the addition of caustic potash and again distilled, when indol and skatol will be distilled over, the phenol remaining behind. Since indol is not so volatile in steam as skatol, the first portion of the distillate will contain the most skatol, and by fractional distillation, one is able to separate the indol from the skatol.

PHENOL.—C_6H_5OH =



Phenol forms long needles which are soluble in fifteen parts of water, melts at 40° C., and boils at 181° C.

1 *Handbuch der Physiol. u. Pathol. Chemischen Analyse*, vii. Aufl. 1903, pp. 217–240.

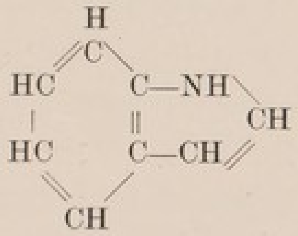
Tests for Phenol.—(1) On heating a solution containing phenol with Millon's reagent, one immediately obtains a red colour or red precipitate.

(2) On adding bromine water to a solution containing phenol, one obtains a milky cloud, which slowly forms a yellowish-white precipitate consisting of silky shiny needles or cheesy flakes of tribromphenol.

$$C_6H_2 \begin{matrix} \diagup Br_3 \\ \diagdown OH \end{matrix}$$

(3) On adding a few drops of perchloride of iron solution to a solution containing phenol (which must have a neutral reaction) one obtains a violet colour, quickly changing to blue.

INDOL.—C_8H_7N =



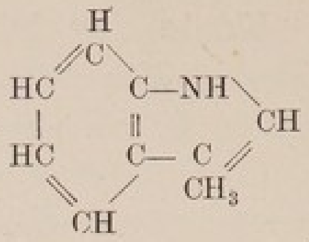
Indol crystallises from hot water as small shiny leaves, with a distinctly fæcal colour, easily soluble in hot and less soluble in cold water. Indol has a melting-point of 52° C. and a boiling-point of 245° C.

Tests for Indol.—(1) A solution containing indol, on adding nitric acid which contains some nitrous acid, gives a red colour, and eventually a precipitate of nitrate of nitrosoindol C_8H_6N (NO). Nitrosoindol is slightly soluble in water, easily soluble in alcohol, and insoluble in ether : on heating to dryness, it explodes.

(2) An alcoholic solution of indol, into which a chip of pine-wood moistened with hydrochloric acid is inserted, gives a cherry-red colour, nitrosoindol.

(3) *Legal's Test.*—To a solution containing indol one adds a very dilute solution of sodium nitro-prusside, and, on the further addition of a few drops of sodium hydrate, one obtains a deep violet colour which turns to blue on the addition of hydrochloric acid or acetic acid.

SKATOL.—(β METHYL INDOL).—C_9H_9N =



Skatol crystallises in colourless leaves which have a fœtid odour and, as we have already said, is less soluble in water and more easily distilled than indol. The crystals of skatol have a melting-point of 95° C. and a boiling-point of 265° C. Skatol readily unites with hydrochloric acid, forming crystals $(C_9H_9N_2)$ HCl., which are insoluble in ether and water and readily soluble in alcohol.

Tests for Skatol.—(1) A solution containing skatol, when nitric acid containing nitrous acid is added, does not give a red colour as when the acid is added to the indol solution, but merely a whitish cloud.

(2) A solution containing skatol on the addition of concentrated hydrochloric acid gives a violet colour.

(3) An alcoholic or water solution of skatol on the addition of a chip of pine-wood moistened with hydrochloric acid gives no red colour, as distinguished from indol. If a chip of pine-wood is put into a hot alcoholic solution of skatol and then into cold concentrated hydrochloric acid, one gets a cherry-red colour which changes into a dark violet.

(4) On the addition of diluted sodium nitro-prusside and a further addition of sodium hydrate, a solution containing skatol gives a yellow colour which, on adding a half-volume of glacial acetic acid and heating to boiling, turns a violet colour.

(5) On warming a solution of skatol with sulphuric acid one gets a purple-red colour.

The above-described methods of recognising the presence of phenol, indol, and skatol may occasionally be of interest, but for diagnostic purposes they are of very little use.

The quantitative estimation of phenol, indol, and skatol is extremely complicated, and we personally have no experience in the matter. The methods are described by Schmidt and Strasburger,[1] and those who desire to carry on the research are referred to these authors.

[1] Schmidt and Strasburger, *Die Fæces des Menschen*, p. 144.

For clinical purposes one can obtain, by the examination of the urine, very valuable information as regards the increase of intestinal putrefaction in connection with the formation of phenol, indol, and skatol. By estimating the quantity of aromatic sulphates in the urine one obtains direct evidence as to whether these aromatic substances are increased or not, as well as which the examination for indican gives satisfactory evidence of the increase or the reverse of this substance. To test for indican in the urine, the following method is sufficient for all clinical purposes.

Test for Indican in the Urine.—To a specimen of urine in a test-tube, concentrated nitric acid is added to the bottom of the test-tube by means of a pipette. A reddish ring appears at the junction of the two layers if indican is present. If it is only slightly in excess, a pink colour appears in five to ten minutes. Excessive indican in the urine is shown by the appearance of the reddish colour immediately the acid is added, which deepens within two or three minutes. When a very marked increase of indican is present in the urine, this red colour becomes almost black on standing.

In making a series of analyses in our laboratory on the amount of indican in the urine as indicated by the nitric acid method, and comparing it with the methods of Jaffe, &c., we have found the nitric acid test to be all-sufficient for clinical purposes.

Presence of Phenol, Indol, and Skatol.—The quantity of phenol, indol, and skatol in the fæces under various pathological conditions has been very little investigated, the subject being a difficult one owing to the want of easy quantitative methods of analysis. On the other hand, it is easy to form an idea of the amount of intestinal putrefaction going on in the alimentary canal, and leading to the production of phenol, indol, and skatol by estimating the indican or the aromatic sulphates in the urine. But it must be remembered that the estimation of the quantity of indican or aromatic sulphates in the urine gives no absolute indication of the amount of phenol, indol, and skatol formed in the alimentary canal, since we do not know what circumstances influence its rate of absorption from the bowel: we therefore only gain definite evidence as to the increase of indican or aromatic sulphates in the urine. There may be no increase in indican or aromatic sulphates in the urine together with increased formation of phenol, indol, and skatol in the alimentary canal, in cases where there is hindered absorption of these substances.

Phenol, indol, and skatol, according to Senator,[1] are not present in meconium, and when one considers that these substances are derived from the breaking-up of proteid by the action of bacteria in the intestine, one would not expect them to be present in meconium, since we know that bacterial putrefaction does not go on in the bowels of the fœtus. The fasting individual, as we have already shown, normally passes a certain amount of fæces which are derived from the digestive secretions in the intestinal canal, the formation of mucus, and the residue of epithelial cells which are continually thrown off from the alimentary tract. These substances, which are more or less rich in proteid, lead to a certain degree of intestinal putrefaction, *i.e.*, phenol, indol, and skatol, which have always been found present in the stools of fasting individuals.

Normal fæces, according to numerous observers, contain a varying quantity of phenol, indol, and skatol, according to the quantity of bacteria present in the intestine—the latter being influenced by the rapidity of transit of food along the alimentary canal and also by the composition of the diet. The diet given to the individual under observation would naturally tend to have a very marked influence on the quantity of phenol, indol, and skatol formed, since we know that these substances are principally derived from the proteid in the food. A diet rich in carbohydrates and poor in proteid would, under normal conditions, tend to form very little of these aromatic substances. On the other hand, a milk diet, though it contains a considerable quantity of proteid, causes a very small quantity of aromatic substances to be present in the fæces, owing to its being made rapid use of in the alimentary canal and leaving a very small residue in the bowels for the action of bacteria. On a purely meat diet, with its increased quantity of proteid, and its tendency to cause constipation, one gets, relatively speaking, a very marked increase in the quantity of phenol, indol, and skatol. The rapid transit of food along the alimentary canal also tends to diminish the quantity of phenol, indol, and skatol, and it is found that even in slight cases of increased peristalsis

[1] *Zeitschr. f. Physiol. Chemie.*, iv. 1880, p. 1.

due to nervous causes there is a marked tendency to decrease in the quantity of aromatic sulphates in the urine as well as in the quantity of indican. A smart purge, such as any of the salines, owing to its effect of hastening the food along the alimentary tract, leads to a diminution in the quantity of phenol, indol, and skatol in the fæces. The most marked reduction of these substances occurs when calomel is given: in such cases we not only have the increased peristalsis tending to cause a diminution in the amount of phenol, indol, and skatol, but we have in addition the action of the calomel on the bacteria of the bowel, as calomel seems, of all drugs, to be the best of the intestinal antiseptics.

In constipation, or where the action of the bowel tends to be sluggish, we should expect to find an increase in the quantity of phenol, indol, and skatol, and it is found in most of these cases that the indican and aromatic sulphates are increased in the urine.

In would appear from the observations of Nothnagel that phenol, indol, and skatol are not so markedly increased in diseases of the large intestine as they are when the disease occurs in the small intestine.

CHAPTER XXII

CHEMICAL EXAMINATION OF FÆCES (*continued*)—BILE, UROBILIN, AND BLOOD

Bile, in the form of bile acids or pigments, may occasionally occur in the fæces, and a few remarks on the subject are necessary here.

Glycocholate and taurocholate of soda are the two principal substances present in the human bile in their passage along the intestine. They are, however, for the most part, absorbed in the small intestine, only a very small proportion of the bile acids passing through the ileo-cæcal valve. The bile acids, on reaching the large intestine, are acted upon by the putrefactive bacteria and broken down into glycocol and taurin; and the cholalic acid united with the soda forms cholate of soda. Consequently, under normal circumstances, no bile acids appear in the fæces.

Cholate of soda, however, is normally present in the stools; but, its pathological significance up to the present being negative, it is unnecessary to describe it here. The method for its recognition is given by Hoppe-Seyler.[1]

Method of Testing for Bile Acids.—In cases where bile acids are present in the fæces, one is able to obtain Pettenkoffer's reaction. A small portion of fæces is placed on some white porcelain, adding a little sugar or a very dilute solution of furfurol, and allowing some concentrated sulphuric acid to come in contact with the fæces on the plate—care being taken that heating does not cause charring. In the presence of bile acids, one obtains a bright crimson colour. This test is not very accurate, however, as the albumen, &c., present in the fæces often mask the reaction.

Presence of Bile Acids.—As already said, the bile acids, under normal conditions, are absorbed or broken up in their passage along the intestine, so that none appear in the

[1] *Handbuch der Physiologisch und Pathologisch Chemischen Analyse, Aufl.* vii, 1903, p. 271.

stools. In cases, however, of very rapid passage of the alimentary contents along the bowel, allowing little time for the action of putrefactive bacteria in the large intestine, bile acids may be found in the fæces.

Bile Pigment.—The recognition of bile pigments in the fæces is a great deal easier than that of bile acids, and consequently is much more generally utilised in practice. In using, in the later parts of this book, the term *bile* as being present in the fæces under pathological conditions, we refer to *bile pigments* and not to bile acids. Bile pigments may be recognised in the fæces either as bilirubin or biliverdin.

Methods of Recognising Bile Pigment: (1) *Schmidt's Reaction.*—This is, undoubtedly, the most decisive method of recognition of bile pigments in the fæces. On the addition of a concentrated solution of corrosive sublimate to either dry or wet fæces, a bright green colour will be obtained if bile is present. This green colour may be obtained even with very small particles of fæces, so that the test can be used as a micro-chemical one. The green colour produced by the sublimate is due to the bilirubin being converted into biliverdin.

(2) *Gmelin's Test.*—Some fæces are smeared on a white tile, and a few drops of nitric acid containing nitrous acid are run on to the edge of the fæces, when, in the presence of bile pigments, a play of colours is produced. Green must be recognised among the colours before one can definitely say that bile pigment is present. If the fæces are coloured green by chlorophyll or bacteria, it is necessary to make a watery extract and allow a drop of nitric acid to come in contact with a drop of the watery solution, when a play of colours will appear if bile is present.

(3) *Huppert's Test.*—About fifteen grams of moist fæces are well mixed with milk of lime and, after shaking, filtered: the precipitate is washed with water until no more colour appears in the filtrate. The precipitate is then collected and extracted with hot alcohol which has been previously acidulated with sulphuric acid. The extract, in the presence of bile, will have a light green colour, due to biliverdin.

Presence of Bile Pigment.—The bile pigments which reach the intestine in their passage along the bowel undergo certain transformations. It is found that the contents of the bowel in the upper third of the small intestine are of a yellowish colour, due to bilirubin; and it has been shown by one of us[1] that the contents in the middle third are of a white or greyish colour, the green colour only appearing again in the lower third of the small intestine. Under ordinary circumstances, when the ileo-cæcal valve is passed, the normal colour of the fæces appears, the bile pigments having been converted by the action of putrefactive bacteria into urobilin. It would appear that in health the bile pigments in the middle third of the small intestine are present in some chromogenic form until they are coloured green after reaching the lower third of the small intestine. Since bile pigments are converted into urobilin after their passage into the large intestine, and, in some cases, even into the lower part of the jejunum, no bile pigment under normal circumstances is present in the fæces. In cases of diarrhœa, more especially the so-called jejunal diarrhœa of Nothnagel, bile pigment is always present in the stools.

UROBILIN

The colouring-matter, urobilin, as it is found in the fæces, has been known by the name of hydrobilirubin or stercobilin; but since the urobilin found in the fæces, when properly purified, has been demonstrated to be identical with the urobilin, when equally purified, that is found in the urine, it seems a pity to complicate matters by giving them different names. We shall, therefore, refer to urobilin in the fæces under the head of urobilin, and not of hydrobilirubin or stercobilin.

Test for Urobilin in the Fæces: *Schmidt's Test.*—When a concentrated solution of perchloride of mercury is applied to either wet or dry fæces, a bright red colour is developed in the space of a few minutes if urobilin is present. The rose-colour extract, when separated and examined with the spectroscope, shows an absorption band of urobilin between F and b. It is possible by this method to recognise very small quantities of urobilin. The colour is distinctly visible on a fragment of fæces after treatment with perchloride of mercury when examined under the microscope. If urobilin is present in very marked

1 Vaughan Harley, "Formation of Urobilin."—*Brit. Med. Journ.*, Oct. 3, 1896.

excess, the pink colour will be very distinct within five minutes, while, in only slight excess, the colour appears within five to fifteen minutes: if only a very little urobilin is present it may be thirty minutes or longer before one gets a reaction, and the most marked reaction will be seen at the end of some twenty-four hours. This test for urobilin is so satisfactory that it is unnecessary to describe the older methods of recognising urobilin in the fæces.

Presence of Urobilin.—In discussing bile pigments we showed how bile pigments are converted into urobilin in the large intestine. The greater part of the urobilin present in the intestinal contents or in the fæces is probably in the form of the chromogen urobilinogen, since we find that in some cases, larger quantities of urobilin are found in the fæces when they have stood for some time. In the case of new-born children, no urobilin is present in the stools or in the urine, meconium being always found to be entirely free from urobilin. In healthy adults, it would appear that under normal conditions urobilin is not found in the bowel until it has reached the ileo-cæcal valve. In autopsies, as a general rule, perchloride of mercury will give a red colour to urobilin in the intestinal wall in the same way as it gives to the fæces a pink colour.[1]

By this method one is able to see where the urobilin is first formed. We have found that, as a general rule, it is not formed until it has passed the ileo-cæcal valve, while in exceptional cases the urobilin formation extends some way up the jejunum.

It has been shown by Gerhardt[2] that in cases of complete obstruction of the bile-duct, the fæces contain no urobilin. In fact, as long as the bile-duct is obstructed, urobilin is absent from the fæces, except in some few cases which are possibly explained by the absorption of bile from the gall-bladder, and the excretion of it into the bowel. That urobilin does not appear in the fæces in obstruction of the bile-duct is of interest in diagnosis. We may describe one case, that of a man with marked jaundice whose fæces contained no trace of urobilin: he was given daily by means of the stomach-tube from 25 to 125 grams of pigs' bile absolutely free from urobilin: on the second day after its administration, urobilin appeared in the fæces, and on the third

1 *Loc. cit.* p. 166.

2 *Ueber Hydrobilirubin und seine Beziehungen zum Ikterus.*—Inaug. Diss. Berlin, 1889.

day, it was detected in the urine: when the administration of bile ceased, urobilin disappeared from the fæces and urine. This clearly demonstrates that the urobilin present in the fæces is derived from the bile in the individual, and, under ordinary conditions, one expects to find urobilin present in the fæces. In cases of increased intestinal putrefaction, there is a tendency to an increase in the quantity of urobilin in the fæces.

The quantity of urobilin in the urine is, to a certain extent, indicative of the quantity formed in the stools, but we must remember that the amount of absorption going on at any time is not exactly proportionate to the amount of urobilin in the bowel, just as the amount of indican does not definitely indicate the amount formed in the intestine.

In meconium, urobilin is always absent and bile pigments only found present. In the case of colourless stools unaccompanied by any jaundice, it is often found that urobilin is absent as such and only urobilinogen is to be recognised; the latter can, by exposure to the air, be converted into urobilin, the fæces then becoming coloured. In the colourless fæces sometimes seen in fat stools, urobilin is present, as a rule, in normal quantities, the colour only being masked by the excess of fat: removal of the fat by ether will at once reveal the colouration.

BLOOD

In blood which is derived from the stomach or from the upper part of the small intestine—unless there is extremely rapid peristalsis and the hæmorrhage is considerable—the oxyhæmoglobin is entirely converted into hæmatin in its passage along the bowels. In hæmorrhages which occur low down in the bowel, such as the rectum, or when the hæmorrhage occurs in the large intestine and there is increased peristalsis, oxyhæmoglobin itself may be present.

Methods of Recognition.—(1) As a general rule, when fresh hæmorrhage occurs and the blood has not been altered by the process of digestion, it can be recognised by the naked eye; or doubtful specimens can be examined under the microscope and red blood corpuscles recognised. If the blood is present in the form of oxyhæmoglobin and the doubtful specimen is dissolved in water, examination with the spectroscope will reveal the two characteristic absorption bands between D 589·3 to 577·8 wave-length and E 556·2 to 528·8 wave-length.

(2) *Guaiacum Test.*—To a watery extract of fæces which appear to contain blood, a few drops of turpentine which has been exposed to the air for some time or some ozonic ether are added. On the addition of a little freshly prepared tincture of guaiacum, one obtains a bright amethyst-blue colour. This test is not very satisfactory for fæces, since they may themselves contain sufficient oxygen carriers to complete oxydation in the absence of blood-corpuscles.

(3) *Teichmann's Hæmin Test.*—When the stools contain blood so altered that it is already formed into hæmatin it is necessary to use further tests, and Teichmann's is one of the most useful. A small specimen of fæces containing blood is placed on a warm glass slide and rubbed up with glacial acetic acid, a trace of sodium chloride being added. After warming over a flame, being careful to avoid over-heating, the preparation is dried, and if examined by the microscope there will be seen, in the presence of blood, the characteristic hæmin crystals as irregular-sized rhombic crystals of a brownish or reddish-brown colour.

(4) *Weber's Test.*[1]—A portion of fæces, after being extracted with ether and all excess of fat removed, is mixed with water and one-third its volume of acetic acid: it is then rubbed up into a fluid consistency, placed in a large test-tube, and ether added. The ether, in the presence of blood, takes up the hæmatin and becomes a brownish-red colour, and if separated can be easily examined with the spectroscope, when it shows the four absorption bands of acid hæmatin: a small marked band in the red between C and D i. 654·7 to 652·6 wave-length, and two fainter bands between D and E ii. 589·3 to 577·8 wave-length and iii. 553.3 to 536·6 wave-length, with a broad band at F iv. 516·8 to 490·6 wave-length, which is very often difficult to see.

Presence of Blood in the Stools.—It is stated that when Weber's test is employed, one obtains a reaction if blood sausages or underdone meat have been taken in the diet. With the ordinary tests, unless raw meat or blood has been taken in the diet, the results are certainly negative. In hæmorrhages from the stomach or small intestine, the blood is intimately mixed with the fæces, and, as already stated, is present in the

[1] *Berl. klin. Wochenschr.*, 1893, No. 19.

form of hæmatin. In some cases of hæmorrhage from typhoid or tubercular ulceration of the bowel accompanied by diarrhœa, one gets oxyhæmoglobin even when the hæmorrhage occurs in the small intestine, the blocd being intimately mixed with the motions. In hæmorrhages from the large intestine, the blood is not so intimately mixed with the fæces, especially if it comes from low down in the bowel; and it is generally found to be more or less mixed with mucus, pus, or some intestinal sloughs from the bowel.

CHAPTER XXIII

MOTOR-POWER OF THE INTESTINAL TRACT—DIARRHŒA AND CONSTIPATION

BEFORE discussing diarrhœa and constipation, it is important to consider the general motility of the bowel.

The frequency of the action of the bowels varies very considerably in different individuals, this being partly due to the mode of life and the diet taken. Any diet leaving a large residue in the bowel tends to cause more or less bulky stools accompanied by frequent motions; so that on a large vegetable diet, or more especially amongst vegetarians, it is not at all uncommon to find a habit of passing two or three motions daily. On the other hand, a diet leaving very little residue, such as milk or meat, tends to diminish the frequency of the motions, so that one may only have an action of the bowels once in two or three days. The knowledge of the peristaltic condition of the alimentary tract is of very great importance to the physician both in the diagnosis and treatment of diseases of the bowels. By noting the time it takes for any easily recognised substance to reappear in the fæces after having been taken by the mouth, one gets an idea of how long it takes for food to pass from the mouth to the anus; but one obtains no clue, in cases of delay, as to how much of the delay is due to want of motor-power in the stomach. In discussing the motility of the stomach, we have already shown how the motor-power of the stomach can be easily investigated; and if the motility of the stomach has been found to be normal, any delay in the appearance of food in the fæces must be attributed to the bowels. On the other hand, if we have found delayed motility of the gastric contents, the amount of delay occurring in the stomach must be subtracted from the total delay in the passage along the alimentary tract, and we shall thus learn how much delay is incurred in the passage along the bowels. In order to make more decisive calculations with regard to the motor-power of the alimentary canal, a diet well mixed with bismuth sub-nitrate has been given and the course of food along the alimentary tract observed by means of X-rays. Sicard and Infroit[1] found by this method that the food took seven hours to pass along the small intestine and reach the ileo-cæcal valve: another period of fourteen hours was required for the passage of food along the cæcum and ascending colon, the rest of the large intestine taking a further period of three hours. The question of whether the large or small intestine is responsible for the delayed motor-power cannot be settled by any method at present known which is applicable to ordinary practice.

In cases of increased peristalsis, one gets, by examination of the fæces, some idea whether the increased peristalsis is in the large intestine; for it is found that when mucus, stained with biliverdin, is present in the fæces, or when, by chemical methods, bile is recognised in the stools, one may conclude that the increased peristalsis is in the large intestine: otherwise, the bile would have been converted into urobilin in its passage along the greater bowel.

Investigation of the motor-power of the alimentary tract by means of the recognition of different particles of food in the fæces is not very satisfactory. The regularity of the motions has long been known by investigators in metabolism not to indicate the rate of passage of substances along the bowel, for it has been found that the fæces passed on any occasion are not necessarily derived from the food taken during the preceding twenty-four hours, and that it is not uncommon to find particles of a former day's food which have remained behind in the sacculi of the colon and have not been passed in the stools which had previously appeared. It is, therefore, necessary in metabolism experiments, where one wishes to separate the stools of the different diets given, to have some means of recognising the fæces belonging to each period. For this purpose, finely ground bone was given by Voit, charcoal and carmine having been given by other investigators. It appeared to us that this method of separating the stools on different diets could be well applied to investigating the motor-power of the alimentary tract, and for the purpose, we have used either finely ground

[1] *La Presse Medicale*, 1903, No. 99.

vegetable charcoal or cachets containing carmine in five-grain doses, the former having been found by us to be the more convenient. Two drachms of vegetable charcoal are dropped into a wineglassful of water and allowed to stand over-night, the charcoal thus getting into fine suspension, being both mixed and swallowed more easily than when simply stirred in milk or water. The mixture is given before breakfast and the motions collected, noting the time when each is passed. A point which makes the charcoal more valuable than the carmine method is that in very dark-coloured motions it is sometimes difficult to recognise the carmine, whereas small particles of charcoal can be easily detected by microscopic examination. The charcoal method of investigating the motility of the bowels has been employed by us for over twelve years, during which time a great number of cases have come under our observation.

In the chart which follows we have put together the results in 518 cases. One notices the wide range of hours which elapse in different individuals before the reappearance of charcoal in the fæces. In no less than four cases it appeared within the first hour after its administration, and this from examination of the patient's symptoms and the chemical analyses was found to be due to increased peristalsis of nervous origin, accompanied by no organic changes in the bowel. On the other hand, we have fourteen cases of chronic constipation in which the charcoal took from 100 to 165 hours to reappear in the fæces: in none of these cases was there any real obstruction in the bowel, and the delayed peristalsis appeared to be due to sluggish action of the bowel from purely functional causes. In rare cases the delay is a great deal longer than this, but we have made no special investigations on this subject, it having been our habit to use enemata or some other means of obtaining the fæces in cases of delay beyond 100 hours.

It is well known that in normal individuals living an ordinary life on a mixed diet there is a tendency to pass a motion every twenty-four hours: it would appear that, by training from youth upwards, the nervous motor-controlling influences of the bowel have become accustomed to operating every twenty-four hours, and thus the habit is produced. We see this very markedly in some individuals who, if they are hindered from relieving their bowels at the usual hour, have to wait till the same hour next day before they can get relief. In the chart we have drawn up, the interesting fact is brought out that there is a tendency—even in cases where there is great delay in the passage of food along the alimentary tract—for the bowels to act at intervals of twenty-four hours. Of the 518 cases examined, the charcoal reappeared in the fæces between the twenty-third and twenty-eighth hours in no less than 174 cases: that is to say, 33·59 per cent. of the individuals observed passed their motions within this period. During the second period of twenty-four hours, of the 279 cases who passed the charcoal at a longer interval than twenty-eight hours after its administration, no less than 100 had an action of the bowels at periods varying from forty-seven to fifty-two hours: that is to say, 35·48 per cent. had an action of the bowel during the second period. During a third period in which 124 cases did not pass their charcoal till after fifty-two hours, the charcoal appeared in no less than thirty-seven of the cases between seventy-one and seventy-six hours: so that 29·83 per cent. passed the charcoal during the third period. During a fourth period, out of thirty-six cases in whose fæces the charcoal did not appear for seventy-six hours, no less than eight, or 22·22 per cent., passed their charcoal during the ninety-sixth hour after its administration by the mouth.

This periodicity of the action of the bowels—even after so long a delay as seventy-six hours—is most interesting and suggestive, as it shows how important it is, in cases of fæcal accumulation where there is no real obstruction, and where one wants to get maximum results with a minimum drug stimulation, to administer drugs or enemata so that they shall act during one of these twenty-four-hour periods.

In some of the above cases where there has been long-delayed appearance of the charcoal, the patients have, in the interval, passed one or more motions belonging to the previous diet. One meets with numerous cases in practice where the patient says that he or she has no constipation since there is a regular action of the bowels. By means of the charcoal method, however, one finds that the passage of food along the alimentary canal requires a longer period than under normal conditions; and only by this method is it possible to recognise that, in spite of the daily motion, there is a long delay in the transit of food along the alimentary canal. In several cases where the chemical examination of the urine and the symptoms of the patient have led one to believe that there was stercoral poisoning, this charcoal method has shown that such was not the case, but that there was a delay in the passage of food along the bowel, in spite of a daily motion having occurred. It will also be found by the charcoal method that scybala, blackened with charcoal, will appear three or more days after the charcoal has been given, and that, in the meantime, stools of normal colour which have evidently passed along the bowel without carrying with them the blackened scybala, have been obtained.

DIARRHŒA

The term diarrhœa does not apply to the frequency of the motions, for we all know of individuals who have three or four motions of a solid consistency daily: the term diarrhœa is more rightly reserved for motions of liquid or pultaceous consistency.

The factors which cause a pultaceous or liquid stool may be grouped under four headings:

(1) The pultaceous or fluid motion due to the increased quantity of water in the fæces, this being a true diarrhœa stool.

(2) The pultaceous motion due to the increased quantity of fat in the fæces, this condition being known as "fat diarrhœa."

(3) The pultaceous motion caused by the increase of mucus.

(4) The pultaceous stool which one gets in various pathological conditions of the bowel, due to organic disease of the mucous membrane of the bowel itself. The latter condition will be described later in treating of various organic diseases.

Diarrhœa Due to the Increased Quantity of Water in the Fæces.—An increased quantity of water in the fæces, rendering them pultaceous, can be produced by any factor which leads to increased peristalsis and rapid hurrying of food along the large intestine. The normal condition of the large intestine with regard to the absorption of water may also be interfered with and thus, without increased peristalsis, give rise to an increased quantity of water in the stools, due to inhibition of the water-absorption power of the large intestine. In cases where there is a rapid hurrying of food along the large and the small intestine, the motions will probably contain some bile pigment which has not been converted into urobilin.

In functional diarrhœa there would appear to be always increased peristalsis, and, if the opportunity arises to administer charcoal, it will be found to appear in the stools very shortly after its administration by the mouth (we have found it in as short a period as fifteen minutes).

General Appearance of the Stools in Diarrhœa.—The motions may vary in colour from a very pale cream to dark chocolate-brown, according to the cause of the diarrhœa, and in some degree, to the diet taken.

The consistency of the motions varies between pultaceous masses and almost pure water. In cases where the diarrhœa is of short duration, it is not uncommon to find some scybala mixed up with the pultaceous motions.

The odour of the stools in diarrhœa varies very considerably. At the commencement of the attack, or where there has been delay in the large intestine, the motions are, as a rule, extremely offensive. But where there is marked peristalsis with frequent motions, the odour steadily diminishes, and in cases of pure jejunal diarrhœa, there may be scarcely any fæcal odour at all.

Chemical Examination of Diarrhœa Stools. *Mucus.*—In most cases of functional diarrhœa mucus in sufficient quantity to be recognised by the naked eye (as described in the macroscopic examination of the fæces) is found to be present. In all cases where there is increased peristalsis of the large intestine, involving the rapid elimination of the contents of the small intestine, mucus will be found intimately mixed with the fæces, and it is not at all uncommon to find it stained more or less green by biliverdin.

Albumen.—In all the cases of diarrhœa which we have examined, we have always found a marked quantity of albumen in a watery extract.

Blood.—In simple diarrhœa, blood or its pigments are not found in the fæces : if it is present, it arises from some extraneous source, such as hæmorrhoids, or it indicates organic disease of the bowel.

Bile.—In cases of diarrhœa, the reaction for bile is not always successful. Bilirubin or biliverdin will be found to give a marked reaction in cases where there has been a very rapid passage of the intestinal contents along the bowel, more especially in cases of jejunal diarrhœa. As already mentioned, it is not uncommon to find mucus stained with bile pigments where there is increased peristalsis in the large and small intestine.

Urobilin.—The chemical examination of the fæces for urobilin will, in most cases of diarrhœa, show only a slight reaction, though at the commencement of the diarrhœa, urobilin may be present in increased quantities. In true cases of jejunal diarrhœa, however, no urobilin reaction will be obtained.

Microscopic Appearances.—The microscopic examination of the fæces shows an increased residue of food, vegetable

TABLE XLIII.—DISEASE—SIMPLE DIARRHŒA

DIET: Mixed + milk, containing 32·82 grams nitrogen, 88·91 grams fat, 131·58 grams carbohydrates, 2207·35 Calories, 2520 c.c. fluid.

Date, Dec. 1900 . .	7	8	9	10	Average.
Weight in kilos . .	61·8	61·8	62·3	62·0	61·9
Calories per kilo . .	35·30	35·30	35·02	35·17	35·19
Urine: Quantitative Analysis					
Quantity . . .	2300	1400	2130	1620	1863
Specific gravity . .	1021	1022	1021	1022	1022
Nitrogen . . .	32·31	23·28	35·06	23·97	28·66
Urea	60·60	45·22	67·13	45·31	54·57
Uric acid. . . .	0·86	0·71	0·87	—	0·81
Ammonia . . .	—	—	—	—	—
Phosphates (P_2O_5) . .	—	3·43	4·96	3·59	3·99
Chlorides. . . .	10·00	7·00	10·48	6·64	8·53
Sulphates: Total . . .	2·22	4·25	6·14	4·31	4·23
Sulphates: Alkaline (A) . .	1·96	4·04	5·85	4·14	4·00
Sulphates: Aromatic (B) . .	0·26	0·21	0·29	0·17	0·23
Sulphates: Ratio A : B . .	7·5 : 1	19·2 : 1	20·0 : 1	24·3 : 1	17·4 : 1
Fæces: Quantitative Analysis					
Date, Dec. 1900 . .	8	9	10	11	Average
No. of Motions . .	2	2	3	2	4 days.
Quantity . . .	361	306	344	118	282
Water per cent. . .	82·97	83·91	84·85	77·00	82·18
Nitrogen . . .	2·73	2·16	2·48	1·21	2·14
Fat	6·58	5·50	6·24	3·03	5·41
Absorbed nitrogen per cent.	—	—	—	—	93·48
,, fat per cent. .	—	—	—	—	93·91

cells, muscular fibres, and increased quantities of fat and starch. Crystals of calcium salts of bile acids, calcium oxalates, and ammonium magnesium phosphate crystals are generally found. The most important microscopic observation in the fæces of diarrhœa is the fact that the mucus present contains few, if any, epithelial cells—this fact enabling one to diagnose the case as one of simple diarrhœa, as against catarrh of the bowels.

Quantitative Analysis of the Fæces in Diarrhœa.—The quantitative analysis of the fæces in cases of diarrhœa may be considered of minor importance. In ordinary slight cases there is usually no increase in the excretion of nitrogen, while in acute cases, more especially those of jejunal diarrhœa, one may expect to find an increased quantity of nitrogen. In children, even in the mildest forms of diarrhœa, such as that accompanying dentition, an increased quantity of fat will be found in the stools.

Simple Diarrhœa.—We had the opportunity of observing in some metabolism experiments an individual who suffered from an attack of diarrhœa during the period of analysis.

In the above case, Table XLIII., a male, aged thirty-seven, suffering from traumatic neurasthenia without any marked intestinal symptoms, had an attack of diarrhœa as indicated by the frequency of the stools and their unformed semi-fluid consistency. During the period of four days' analysis, the first charcoal given took no less than fifty-two hours to appear in the stools, the motion at that time being well-formed rolls, coloured black by charcoal. Six hours later, a brown, unformed, pultaceous motion was passed, and, in the next two days, the patient passed two or three motions daily. The second charcoal was given on the fourth day, and took sixty hours to appear in the motions. The last motions before the appearance of the second charcoal were dark-brown formed rolls of a normal consistency. It is seen on looking at the table that the last-formed motion contained only 77 per cent. of water: on the previous day, on which there were three motions, the percentage of water was 84·85 per cent. The analysis of the first day was rather vitiated by the fact that the second motion, which was unformed, was mixed with the first charcoal-formed motion and the two analysed together. We see that in this case the quantity of fæces was very markedly increased during the time that the diarrhœa occurred, as also the quantity of water—since on an ordinary mixed diet, with the addition of milk, the average percentage of water in the fæces is found to be 74 per cent.

The quantity of nitrogen in the fæces is seen to be increased on the days of diarrhœa, being more than 2 grams per diem, while on the last day of normal fæces the nitrogen was only 1·21 grams. We have shown that the average daily quantity of nitrogen present in the fæces on a mixed diet with the addition of milk is about 1 gram, so that in this case of diarrhœa from no apparent cause

TABLE XLIV.—DISEASE—SIMPLE DIARRHŒA

DIET: Milk, containing 15·77 grams nitrogen, 92·82 grams fat, 99·96 grams carbohydrates, 1677·09 Calories, 2380 c.c. fluid

Date, July 1904	17	18	19	20	Average.
Weight	82·01	82·67	81·45		81·71
Calories per kilo	20·45	20·53	20·59		20·52
Urine: Quantitative Analysis					
Quantity	440	570	570		527
Specific gravity	1026	1030	1027		1028
Nitrogen	10·74	14·42	14·24		13·13
Urea	22·76	28·96	30·09		27·27
Uric acid	0·19	0·36	0·41		0·32
Ammonia	0·78	1·27	1·65		1·23
Phosphates (P_2O_5)	2·49	3·05	2·46		2·69
Chlorides	2·21	2·86	2·86		2·64
Sulphates: Total	1·89	1·96	1·85		1·90
Sulphates: Alkaline (A)	1·73	1·75	1·63		1·70
Sulphates: Aromatic (B)	0·16	0·21	0·22		0·20
Sulphates: Ratio A : B	10·8 : 1	8·3 : 1	7·3 : 1		8·5 : 1
Fæces: Quantitative Analysis					Average 3 days.
No. of motions	2	4	1	1	
Quantity	972	713	174	426	742
Water per cent.	93·25	94·85	94·68	95·10	94·47
Nitrogen	2·23	1·25	0·31	0·79	1·53
Fat	4·75	2·67	0·67	1·69	3·26
Absorbed nitrogen per cent.	—	—	—	—	89·92
,, fat per cent.	—	—	—	—	96.49

and probably entirely due to increased peristalsis of the intestine, the quantity of nitrogen excreted was increased to double its normal amount. Instead of the normal proteid absorption of about 95 per cent., the average in this case was 93·48 per cent.—not a marked decrease when one considers the quantity of nitrogen present in the fæces. The fat in the stools during the time that the diarrhœa lasted was large in amount, being 6 grams per diem, while on the fourth day, on which one motion only was passed, there was only 3·03 grams of fat. On referring to the normal absorption on such a diet, we see that the last day corresponds with what is usually found in normal cases, while on the other days it is diminished. The normal absorption on such a diet is, roughly, 96 per cent., while in this case the absorption is diminished, being 93·91 per cent.

The analysis of the urine is given in the table, but it is unnecessary to go into details.

We will now consider a case of simple diarrhœa (Table XLIV.) which lasted throughout the period of observation, the patient being on a milk diet.

In this case, on the two occasions on which charcoal was given —at the commencement and end of the period of three days— the charcoal appeared in the fæces in two hours the first and in three and three-quarter hours the second time of administration. The colour of the fæces (when not blackened by charcoal) was creamy-yellow, and, although the bulk of the charcoal was passed in the two motions of the first day, traces were still to be found on the second day. The consistency of the motions throughout was pultaceous, and the odour very offensive.

The chemical examination of the fæces showed a marked increase of mucus and of albumen : no blood or bile was present and throughout, the urobilin was in excess.

The microscopic examination showed very few epithelial cells mixed up with mucus ; so that this case, in spite of the frequent motions and their fluid consistency, could not be diagnosed as catarrh of the bowel. The history and progress of the case confirmed the diagnosis of simple diarrhœa.

The urine analysis showed nothing to help the diagnosis of the bowel disorder except a tendency to increased intestinal putrefaction, and the daily quantity of urine was very small. On the same diet, when no diarrhœa was present, this patient passed an average of 1285 c.c. of urine per diem.

The quantitative analysis of the fæces, on the other hand, showed a very marked excess in the quantity of water. Instead of the normal average of 76 per cent., we have the high average of 94·47 per cent. of water, due, in all probability, to hyperæmia accompanying the increased peristalsis.

There was a distinct increase in the daily elimination of nitrogen by the bowel, so that the absorption, instead of being normal—*i.e.*, 95 per cent. on a milk diet—was only 89·92 per cent. The fat in the stools showed a slight tendency to increase, averaging 3·26 grams, and there was only a slightly diminished fat absorption, the average being 96·49 per cent.

Nervous Diarrhœa.—Having discussed a case of simple diarrhœa, due to increased peristalsis, with probably no vasa-motor changes in the intestine leading to hyperæmia and hence only a slight increase in the quantity of fluid in the motions, and a second case accompanied by hyperæmia, we now pass on to purely nervous diarrhœa which would appear to be accompanied by—in addition to increased peristalsis—marked vasomotor changes in the large intestine, leading to hyperæmia and causing an excessive flow of water into the bowels. It would appear that nerve shock or fright causes in certain individuals a sudden fluid motion; and in others the anxiety of railway travelling when no lavatory carriage is supplied and other mental conditions are known to all of us to cause diarrhœa.

We now give a very interesting case of a naval officer, aged fifty, who suffered from general nervousness and complained of flatulent dyspepsia, accompanied by severe belching, which was cured by a cork.[1] He was periodically troubled with severe attacks of diarrhœa, and we were able to get some analyses on these occasions. Taking one day's record, we find that he had motions as follows:

2.25 A.M.	Bowels moved.
6 A.M.	Bowels moved, preceded by a great deal of belching.
9.25 A.M.	Bowels moved.
9.40 A.M.	Bowels moved, with some intestinal flatulency.
10.15 A.M.	Bowels moved.
1.15 P.M.	,, ,,
2.45 P.M.	,, ,,
4 P.M.	,, ,,
4.45 P.M.	,, ,,
5·10 P.M.	Bowels moved. When massaged, said he felt the wind very badly, nearly choking him.
6 P.M.	Bowels moved.
6.15 P.M.	,, ,,
7.15 P.M.	,, ,,
8.10 P.M.	,, ,,
9.20 P.M.	,, ,,
10.0 P.M.	,, ,,
11.0 P.M.	,, ,,

[1] *See* p. 41.

On some occasions when he complained of a great deal of wind in the stomach, very little was found on examination: on other occasions the stomach was distended. During the remaining days of the period of observation, there were only two or three motions, and then there would be periods of freedom from diarrhœa. Charcoal was given on six occasions, and was found to appear in the motions as follows:

1st	Charcoal	appeared	2½ hours	after	administration.
2nd	,,	,,	1 hour	,,	,,
3rd	,,	,,	4 hours	,,	,,
4th	,,	,,	25 minutes	,,	,,
5th	,,	,,	2 hours	,,	,,
6th	,,	,,	15 minutes	,,	,,

The motions were of uniform consistency, coloured black by charcoal and containing a little mucus. In the intervals between

TABLE XLV.—DISEASE—NERVOUS DIARRHŒA

DIET: Milk containing 19·48 grams nitrogen, 114·66 grams fat, 123·48 grams carbohydrates, 2069·76 Calories, 2920 c.c. fluid

Date, January 1902	19	20	21	Average.
Weight in kilos	80·78	80·33	79·88	80·33
Calories per kilo	25·62	25·77	25·91	25·77
Urine: Quantitative Analysis				
Quantity	1820	1040	730	1197
Specific gravity	1020	1018	1023	1020
Nitrogen	21·11	10·82	12·12	14·68
Urea	36·95	19·57	23·21	26·58
Uric acid	0·50	0·39	0·58	0·47
Ammonia	0·35	0·68	0·81	0·61
Phosphates (P_2O_5)	4·00	2·70	3·29	3·33
Chlorides	9·10	3·85	2·95	5·31
Sulphates: Total	3·55	2·14	2·01	2·57
Sulphates: Alkaline (A)	3·40	2·04	1·83	2·42
Sulphates: Aromatic (B)	0·15	0·10	0·18	0·15
Sulphates: Ratio A : B	22·7 : 1	20·4 : 1	10·2 : 1	16·1 : 1
Fæces: Quantitative Analysis				Average 3 days.
No. of motions	14	15	14	
Quantity	545	1181	1307	1011
Water per cent.	91·15	93·39	93·68	92·74
Nitrogen	1·49	2·42	2·55	2·16
Fat	6·23	10·11	10·70	9·01
Absorbed nitrogen per cent.	—	—	—	88·91
,, fat per cent.	—	—	—	92·14

the charcoals the motions were thin and liquid, of a light yellowish-brown colour, sometimes containing mucus (though never in any large quantity): albumen and urobilin were always present, and occasionally a biliverdin reaction was obtained. There was no blood and, microscopically, there were remnants of food, with a few crystals but no marked increase of epithelial cells.

In Table XLV. it is seen that during the three days of analysis on a milk diet there were very numerous motions—fourteen and fifteen per diem. The first charcoal given appeared in two and a half hours, while the last appeared in one hour. The urine analysis showed no increase of aromatic sulphates, and, in spite of the great degree of diarrhœa, there was no marked decrease in the quantity of urine passed daily; but this is accounted for by the large quantity of fluid taken. On the three days when the fæces were analysed the average quantity per diem was no less than 1011 grams, containing 92·74 per cent. of water. The nitrogen in the fæces averaged 2·16 grams, so that the absorption was very markedly decreased, being only 88·91 per cent. The fat in the fæces varied considerably on the different days, the average being 9·01 grams per diem: the average absorption of fat was also diminished, being only 92·14 per cent.

The patient was then put on a pure meat diet (Table XLVI.), the quantity he was able to take being very small—only 9·16 Calories per kilo, body-weight. During this time he steadily lost weight, though the loss was, comparatively speaking, slight. Analysis of the urine showed that more nitrogen was daily eliminated than was taken in the diet. The uric acid was larger than that found on the milk diet, though certainly not above a normal average. The aromatic sulphates remained the same as on the milk diet. The analysis of the fæces showed the motor-power of the alimentary tract to be not quite so accelerated as on the milk diet, since the first charcoal did not appear until four hours after its administration by the mouth—the second charcoal, on the other hand, appearing in as short a time as twenty-five minutes. The quantity of fæces on this pure meat diet was considerably diminished, the motions varying in number from one to five per diem, but the quantity averaging only 178 grams. The stools were reddish brown, consistency fluid paste, containing some mucus and a considerable quantity of albumen.

TABLE XLVI.—DISEASE—NERVOUS DIARRHŒA

DIET: Meat, containing 14·72 grams nitrogen, 36·68 grams fat, 0 grams carbohydrates, 718·32 Calories, 1680 c.c. fluid

Date, January 1902 . .	24	25	26	27	Average.
Weight in kilos . .	78·75	78·53	78·30	78·30	78·47
Calories per kilo . .	9·12	9·15	9·19	9·19	9·16
Urine: Quantitative Analysis					
Quantity . . .	950	940	840	840	893
Specific gravity . .	1028	1027	1028	1026	1027
Nitrogen . . .	—	21·53	19·57	19·24	20·11
Urea	44·45	39·05	38·22	37·38	39·78
Uric acid. . . .	0·43	0·45	0·33	0·82	0·51
Ammonia . . .	0·42	0·23	0·26	0·19	0·28
Phosphates (P_2O_5) . .	2·60	1·89	2·18	1·60	2·07
Chlorides. . . .	0·87	1·69	0·77	1·34	1·17
Sulphates: Total . . .	4·08	3·91	3·98	4·11	4·02
Sulphates: Alkaline (A) . .	3·90	3·75	3·84	3·98	3·87
Sulphates: Aromatic (B) . .	0·18	0·16	0·14	0·13	0·15
Sulphates: Ratio A: B. . .	21·7 : 1	23·4 : 1	27·4 : 1	30·6 : 1	25·8 : 1
Fæces: Quantitative Analysis					Average 4 days.
No. of motions . .	4	5	2	1	
Quantity . . .	418	98	132	62	178
Water per cent. . .	93·82	91·33	91·33	91·33	91·95
Nitrogen . . .	1·42	0·48	0·63	0·29	0·70
Fat	5·14	1·69	2·27	1·07	2·54
Absorbed nitrogen per cent.	—	—	—	—	95·24
,, fat per cent. .	—	—	—	—	93·07

Bile pigments could not be demonstrated, and urobilin was always found present. The water was very largely increased, being no less than 91·95 per cent., while we have found the average quantity of water on this diet to be 74 per cent. There was no great increase in the quantity of nitrogen, but the fat was double the quantity which we have found in our normal cases. The absorption of proteid was apparently increased, being 95·24 per cent., while the fat absorption was decreased to 93·07 per cent.

During a third period another analysis of the same individual was done on a mixed diet (Table XLVII.), when he took thirteen Calories per kilo, body-weight; and on this small diet he increased slightly in weight. During this period it was found that he was

TABLE XLVII.—DISEASE—NERVOUS DIARRHŒA

DIET: Mixed, containing 19·00 grams nitrogen, 47·16 grams fat, 40·93 grams carbohydrates, 1064·99 Calories, 1260 c.c. fluid

Date, February 1902 .	13	14	15	16	Average.
Weight in kilos . .	77·62	77·40	78·30	78·30	77·90
Calories per kilo . .	13·72	13·76	13·60	13·60	13·67
Urine: Quantitative Analysis					
Quantity . . .	500	1060	950	880	847
Specific gravity . .	1028	1032	1031	1029	1030
Nitrogen . . .	10·57	23·58	19·48	17·16	17·69
Urea	18·69	43·14	33·06	28·16	30·76
Uric acid . . .	0·48	1·37	0·90	0·88	0·90
Ammonia . . .	0·61	1·06	0·93	0·97	0·86
Phosphates (P_2O_5) . .	1·20	2·76	2·35	2·20	2·12
Chlorides. . . .	2·74	5·30	6·46	5·19	4·92
Sulphates Total . . .	1·85	5·03	3·38	3·11	3·34
Sulphates Alkaline (A) . .	1·72	4·72	3·13	2·93	3·12
Sulphates Aromatic (B) . .	0·13	0·31	0·25	0·18	0·22
Sulphates Ratio A : B. . .	13·2 : 1	15·2 : 1	12·5 : 1	16·2 : 1	14·2 : 1
Fæces: Quantitative Analysis.					Average 4 days.
No. of motions . .	2	2	1	2	
Quantity . . .	89	129	70	204	123
Water, per cent. . .	89·78	89·78	89·78	88·55	89·41
Nitrogen . . .	0·55	0·80	0·44	1·38	0·79
Fat	1·61	2·34	1·27	4·02	2·31
Absorbed nitrogen per cent.	—	—	—	—	95·84
,, fat per cent.	—	—	—	—	95·10

practically on nitrogen equilibrium, in spite of having a tendency to diarrhœa, the motions being hardly increased in frequency, but the quantity of fluid being above the normal. On the two occasions on which charcoal was given, the first appeared in two hours and the second in fifteen minutes. It is interesting to note in this individual, during the three periods of analysis, how considerably the rates varied at which the charcoal passed through the alimentary tract; and as there was no evidence, in the examination of the fæces, of pathological changes to account for this, the case appears to us to be a typical one of nervous diarrhœa.

Stercoral Diarrhœa.—In patients suffering from habitual constipation, it is not at all uncommon to find periodical attacks of diarrhœa. In some of these cases it would appear that the stagnated fæcal masses set up a local catarrh from some mechanical pressure, thus causing diarrhœa. There are cases, however, without any organic alterations in the bowel where the liberation of marsh and other gases from the fæcal lumps cause, by their stimulation, increased peristalsis of the bowel.

TABLE XLVIII.—DISEASE—STERCORAL DIARRHŒA

DIET: Mixed + milk, containing 17·41 grams nitrogen, 124·21 grams fat, 121·96 grams carbohydrates, 2105·93 Calories, 1710 c.c. fluid

Date, June 1904	12	13	14	15	Average.
Weight in kilos	75·60	75·15	75·15	75·12	75·25
Calories per kilo	27·85	28·02	28·02	28·03	27·98
Urine: Quantitative Analysis					
Quantity	1800	1300	1540	1290	1475
Specific gravity	1014	1020	1019	1022	1019
Nitrogen	13·50	14·01	16·92	14·97	14·85
Urea	26·28	26·91	32·18	29·54	28·73
Uric acid	0·40	0·38	0·17	0·24	0·30
Ammonia	0·09	0·25	0·42	0·51	0·32
Phosphates (P_2O_5)	2·14	2·27	3·29	2·76	2·61
Chlorides	9·00	7·58	6·33	7·65	7·64
Sulphates: Total	2·59	2·75	3·11	2·81	2·81
Sulphates: Alkaline (A)	2·40	2·57	2·94	2·61	2·63
Sulphates: Aromatic (B)	0·19	0·18	0·17	0·20	0·18
Sulphates: Ratio A : B	12·6 : 1	14·3 : 1	17·3 : 1	13·0 : 1	14·3 : 1

Fæces: Quantitative Analysis

Date, June 1904	13	14	15	17	18	Average
No. of motions	1	2	2	2	1	4 days.
Quantity	216	74	40	344	229	226
Water per cent.	77·90	82·28	74·30	96·61	93·29	84·84
Nitrogen	2·77	0·76	0·60	0·68	0·89	1·43
Fat	12·46	3·40	2·67	3·03	4·00	6·38
Absorbed nitrogen p.c.	—	—	—	—	—	91·78
,, fat per cent.	—	—	—	—	—	93·25

In Table XLVIII. a case of stercoral diarrhœa is exhibited. The motions, on ordinary occasions, were formed rolls made up of masses of scybala, and were only passed at intervals of three or four days—or at even longer intervals when no drugs were taken. The patient had, in consequence of this constipation, been in the habit of taking purgatives, and even then was unable to obtain a daily evacuation. When the attack of diarrhœa occurred, motions of unformed paste, containing a few scybala, were passed, and this continued for two or three days, after which there was a return to the constipation. The analysis of the urine merely showed an increase of indican, and no albumen or sugar was present. On referring to Table XVLIII., it is seen that the aromatic sulphates were not increased. The quantity of phosphates was normal, while the chlorides were seen to be increased. In spite of the patient taking an ordinary mixed diet with the addition of milk, the uric acid excretion was remarkably small, although the output of nitrogen and urea was normal. The ammonia excretion progressively increased.

In the analysis of the fæces the first charcoal was found to appear in twenty-eight hours after its administration, while the second charcoal took no less than forty-one hours. On testing the motility of the bowels on an earlier occasion, when there was no tendency to diarrhœa, the charcoal did not appear till seventy hours after its administration.

The ordinary motions were short, dark-brown rolls, either made up of scybala intermixed with mucus, or separate scybala. The first motion passed after the charcoal consisted of black, unformed soft paste, containing numerous scybala and of an extremely offensive odour. The subsequent motions were greenish-brown paste (that passed on the seventeenth being almost fluid) and contained some formed rolls or scybala, the odour being very offensive.

Mucus was increased in all the motions, and the albumen reaction was very marked. Blood was occasionally present, while bile was absent and urobilin increased. The microscopical appearances included numerous vegetable cells, muscular fibres and starch granules, numerous crystals of ammonium magnesium phosphate, calcium salts of bile acids, a few epithelial cells, and some leucocytes.

The quantitative analysis of the fæces showed that the daily quantity varied from 40 to 344 grams, containing from 74·30 to 96·61 per cent. of water. The fæces contained a varying quantity of nitrogen, and on the day on which the greatest quantity of fæces, with the greatest quantity of water, was passed, only 0·68 grams were present, while on the first day, no less than 2·77 grams of nitrogen were contained in the fæces, the daily average being 1·43 grams. The quantity of fat varied from 2·67 to 12·40 grams in the twenty-four hours, the average being 6·38 grams. The absorption of both nitrogen and fat was very markedly decreased, being respectively 91·78 and 93·25 per cent.

The only remarkable point in the analysis is the presence of blood in the motions; otherwise, the analysis is very similar to that of ordinary diarrhœa. It was considered, however, that the blood was not due to ulceration or very advanced catarrh, since there was no evidence of pus cells and only a very few epithelial cells and leucocytes were present: the case may, however, be put down as on the borderland.

Dyspeptic Diarrhœa.—Under the heading of dyspeptic diarrhœa may be grouped certain attacks of diarrhœa which are due to errors in diet. Some of these cases are probably due to the diet, from mechanical reasons, causing increased peristalsis of the bowel, while in other cases, increased peristalsis of the bowel may be excited by the products of the fermentation of the carbohydrates, leading to the excessive production of irritable acids, such as butyric, lactic, and acetic acids. Further, from the putrefaction of the proteids, sulphuretted hydrogen or other gases may be liberated and cause increased intestinal peristalsis (Bokki). In so-called "fat-diarrhœa" Tschernoff[1] describes a case in which the quantity of fat was increased even to 48 per cent. These attacks of dyspeptic diarrhœa are especially common after taking certain articles of food; turnips, cabbages, pickles, fresh fruit (especially if unripe), are all liable to set up this form of diarrhœa. The chemical examination of the motions shows nothing of great importance, and we have never had an opportunity of doing a quantitative analysis in a typical case of the kind.

CONSTIPATION

In discussing intestinal motility, we showed that in normal individuals, the bowels tended to act every twenty-four hours, and that the passage of food along the small intestine was very rapid, the delay occurring in the descending colon and sigmoid flexure, the fæces remaining there until expelled at twenty-four-hour intervals into the ampulla of the rectum, where they produce a sensation of desire for defecation. In cases of long

[1] *Jahrbuch f. Kinderheilkunde*, vol. xxviii. 1888, p. 1.

retention in the ampulla of the rectum, masses of scybala may cause tenesmus. Physiological variations in the frequency of action of the bowels are very considerable, and some people have an action only once in two or three days, while Reichmann[1] describes cases of normal individuals feeling perfectly well, and having an action of the bowels only once in two or three weeks or at even longer intervals. It is impossible for us to discuss here all the various causes of constipation. Obstinate constipation may of course arise when there is a physical obstruction pressing on the bowels themselves, or when there are physical changes in the muscular structure of the bowel, such as atrophy; or, in rare cases, where there is great lengthening of the large intestine.

The functional cases of constipation due to delayed peristalsis may conveniently be considered here, since the action of the bowel in health is dependent on the peristalsis of the muscles of the bowel, together with the action of the extrinsic muscles which are called into play in the act of defecation. The peristalsis of the bowel is stimulated to a certain extent by the composition and amount of residue present in the intestine, so that diet plays a very important *rôle* in this stimulation. A diet consisting principally of vegetable material, since it contains a large quantity of cellulose, leaves a large residue in the bowel, which from its mechanical size alone tends to stimulate peristalsis. On the other hand, a diet consisting of meat or milk, both of which are easily digested, and leave a very small amount of residue to stimulate the bowel, are apt to cause sluggishness. A carbohydrate diet, even if finely prepared, causes the formation of various acid products, such as butyric, lactic, and acetic acids, and although there is very little residue left for mechanical stimulation, yet these acids appear to stimulate peristalsis. The extrinsic muscles which act in defecation may lose a certain amount of tone from giving up any habitual exercise, such as riding or walking, or any exercise which makes one use the diaphragm, and in some cases the taking of regular physical exercise helps the bowels to act. At the same time, constitutional variations must be borne in mind, since one finds habitual constipation in individuals who lead a healthy out-door life with plenty of exercise. In neurasthenia, just as there is a

[1] Quoted Nothnagel's *Darmkrankheiten.*

tendency to dilatation of the stomach or gastroptosis due to want of muscular tone, so there may be enteroptosis and loss of tone in the large intestine, leading to constipation.

Constipation Fæces.—The stools in constipation are very varied in form, from hard rolls to scybala matted together in sausage-shaped masses like sheeps' motions, or separate small lumps of scybala varying in size from a pea to a nut. These scybala are sometimes so hard that they rattle in a pan with a distinct metallic sound; they are often coated with a mucus of a very thick and tenacious consistency, and it is not at all uncommon to find streaks of blood in the mucus. The colour of the scybala varies from dark brown to almost black, except when the patient is on a milk diet, when one finds a slaty-grey colour.

Markedly delayed motility is easily recognised by giving charcoal, and, in some cases, there is a very long interval between its administration and the appearance of the charcoal in the stool. If charcoal does not appear after about 100 hours, one has obtained sufficient information on the point, and the patient can be relieved by enemata or purgatives. The odour of ordinary scybala, considering the length of time they have been retained in the bowel, is not, as a rule, very offensive. If there is no catarrhal affection of the bowel, and no greatly increased intestinal putrefaction, there may be little or no odour in scybala even after long retention. If, however, the above conditions are present, one gets increased formation of indol, phenol, and skatol, leading to a very foul stool. This lack of odour is partly due to the dryness of the fæces, and in constipation cases, where the motions have been accelerated by purgatives, foul-smelling fæces are often found.

The chemical analysis of the fæces in constipation shows that mucus is nearly always present, but the mucus coats the fæces, and is not intimately mixed with the scybala as one finds in catarrh.

Albumen is not, as a rule, obtained in the watery extract of constipation fæces.

Blood, as already mentioned, is not uncommonly found in streaks, generally arising from injury in the passage of the motions. In cases of congestion of the liver, where one has venous engorgement of the intestine, so often accompanied by chronic constipation, one sometimes finds blood pigment intimately mixed with the stool; also, in cases of duodenal ulceration or ulceration of the stomach, the same may occur. But, in functional constipation, no blood is found intimately mixed with the scybala.

The examination of the fæces for bile invariably gives a negative reaction. When examined for urobilin, the scybala generally show a tendency to excess.

The microscopic appearances in constipation fæces appear to be of little importance. According to the diet, one finds a certain amount of partially digested muscular fibre. On a Schmidt's diet, one always finds some muscular fibre, and generally some starch granules, with a few fat drops, or even fat crystals. On an ordinary mixed diet, remains of vegetable cells, epithelial cells and leucocytes are found, the latter especially if there is any tendency to catarrh of the bowel, or retention of the scybala, causing irritation of the mucous membrane.

Crystals of ammonium magnesium phosphate, and, in some cases, of oxalate of lime, are present, and it is not at all uncommon to find numerous cholesterin crystals.

The quantitative analysis of the fæces shows, as a rule, a very marked decrease in the quantity of water, which varies from 50 to 70 per cent. The total nitrogen and fat in the fæces are, as a rule, found to be perfectly normal, and one may say also that the absorption of nitrogen and fat does not vary very much from what we have already stated to be the normal absorption; and this, in spite of the long retention in the bowel.

Simple constipation may have little effect on the patient, while in other cases, individuals are so susceptible to the retention of fæces that if they miss a daily action of the bowels, they suffer from headache or other symptoms all day, these being due to auto-intoxication from the absorption of products of putrefaction from the bowel.

We will now describe two cases, one of habitual constipation in which no symptoms were produced by the constipation itself, and another in which marked symptoms accompanied it.

A lady suffering from Graves' Disease, but with no symptoms of indigestion, had always had a tendency to constipation. Analyses were carried out during two periods. The first charcoal appeared in 108 hours and 10 minutes after its administration, and three days later, carmine was given as an indicator, the latter appearing in the fæces in 165½ hours. The charcoal mostly appeared in the first motion five days after being given by the mouth, the motion consisting of 26 grams of scybala, only partially matted together. Between the first appearance of charcoal and the carmine appearance on the tenth day, four

TABLE XLIX.—DISEASE—CHRONIC CONSTIPATION

DIET: Mixed, containing 15·88 grams nitrogen, 77·69 grams fat, 85·78 grams carbohydrates, 1483·64 Calories, 1400 c.c. fluid

Date, May 1904	23	24	25	26	27	28	Average.
Weight in kilos	43·20	42·53	42·41	42·30	42·30	41·86	42·43
Calories per kilo	34·11	34·88	34·98	35·07	35·07	35·43	34·82
Urine: Quantitative Analysis							
Quantity	1040	950	1260	1000	1030	1120	1093
Specific gravity	1020	1020	1020	1022	1022	1018	1020
Nitrogen	15·70	—	20·29	17·42	17·20	16·24	17·37
Urea	29·74	33·80	39·69	31·50	34·09	32·48	33·55
Uric acid	0·94	0·60	0·82	0·78	0·67	—	0·76
Ammonia	0·60	0·33	0·63	0·43	0·52	0·55	0·51
Phosphates (P_2O_5)	2·23	1·96	2·61	2·23	2·13	2·05	2·20
Chlorides	5·72	4·75	5·17	4·10	4·22	4·14	4·68
Sulphates. Total	3·06	2·92	3·59	3·19	2·83	2·87	3·08
Sulphates. Alkaline (A)	2·98	2·86	3·33	3·08	2·73	2·79	2·96
Sulphates. Aromatic (B)	0·08	0·06	0·26	0·11	0·10	0·08	0·12
Sulphates. Ratio A : B	37·3 :1	47·7 :1	12·8 :1	28·0 :1	27·3 :1	25·0 :1	24·6 :1

Fæces: Quantitative Analysis

Date, May 1904	26	27	29	30	Average
No. of motions	2	1	1	1	6 days.
Quantity	65	27	200	195	81
Water per cent.	54·78	53·82	74·23	74·23	64·27
Nitrogen	1·39	0·68	2·42	2·36	1·14
Fat	6·02	2·92	10·53	10·26	4·96
Absorbed nitrogen per cent.	—	—	—	—	92·82
,, fat per cent.	—	—	—	—	93·62

small motions were passed, the total containing 123 grams, and the quantities varying from 16 to 43 grams. The scybala were dark greenish brown and extremely hard, the fæces being found to contain only 55·86 per cent. of water.

Another period of six days was analysed, the patient having, in the interval, received massage, which somewhat diminished the constipation. In Table XLIX. the results are given.

During the period on a mixed diet when 34·82 Calories per kilo were taken, the patient did not gain weight, and it is seen that the average quantity of nitrogen in the urine and fæces was greater than the intake. The nitrogen and urea in the urine varied considerably, the quantity of uric acid being practically normal, while the ammonia was increased.

The first charcoal appeared in 85 hours, and the second in 61½ hours. Despite this delay, the urinary analysis showed no increase in aromatic sulphates, though there was some increase of indican. The fæces were greenish brown, and consisted of hard lumps matted together so as to form rolls, having the appearance of sheeps' motions, and, considering their dryness, they were very offensive. Mucus was increased, and albumen was found to be present. No blood or bile could be recognised. The urobilin was slightly increased, although, on some days, only a slight reaction was obtained. The microscopic appearances included nothing of note, only a few epithelial cells being present, so that there was evidently no marked catarrh.

The daily quantity of fæces varied considerably, and the motions obtained on the 29th and 30th occurred after the administration of a pill. The first natural motions contained 54·78 and 53·82 per cent. of water, while those after the pill contained 74·23 per cent.

The nitrogen in the normal motions varied from 1·39 to 0·68 grams, and the fat from 1·02 to 2·92 grams in the twenty-four hours. In spite of the administration of the pill, the average quantity of nitrogen was 1·14 grams, and that of fat 4·96 grams. The absorption during the period was considerably decreased.

The second case was that of a male, aged forty-six, who suffered from general debility, his skin having the markedly yellow tinge so often noticed in chronic constipation. It had been considered that he might be suffering from malignant disease and marked anæmia. He gave a history of constipation of many years standing, and a tendency to a weak heart. The heart was found to be somewhat dilated with soft blowing murmurs in the mitral area, but no other signs of cardiac failure could be detected. The blood count, in spite of the markedly anæmic appearance, was as follows:

Hæmoglobin	78
Red blood corpuscles	4,380,000
Leucocytes	9,000
Ratio	487 : 1

The patient was put on an ordinary mixed diet, and on the evening previous to the administration of charcoal, he was given a Pil. Col. et Hyoscy. The first charcoal did not appear in the fæces for 78 hours, and the second charcoal, which was given at the end of five days, did not appear for 51 hours and 20 minutes, and was only then obtained by giving a Pil. Col. et Hyoscy. During the period of five days the patient only passed three motions, of which the first two only can be regarded as constipation stools, the third appearing after a pill had been given.

TABLE L.—DISEASE—CHRONIC CONSTIPATION

DIET: Mixed + milk, containing 21·14 grams of nitrogen, 111·60 grams fat, 145·30 grams carbohydrates, 2087·30 Calories, 1790 c.c. fluid

Date, March 1905	13	14	15	16	17	Average.
Weight in kilos	80·10	79·88	81·00	80·78	80·78	80·51
Calories per kilo	26·06	26·13	25·77	25·84	25·84	25·93
Urine: Quantitative Analysis						
Quantity	1120	1330	1090	1580	1130	1250
Specific gravity	1020	1022	1024	1020	1022	1020
Nitrogen	17·14	18·09	20·60	18·64	20·10	18·91
Urea	35·73	36·31	34·66	38·55	35·37	36·12
Uric acid	0·62	0·81	0·65	0·33	0·62	0·51
Ammonia	0·55	0·23	0·53	0·66	0·45	0·48
Phosphates (P_2O_5)	2·32	2·26	2·94	3·64	2·37	2·71
Chlorides	4·14	5·45	4·47	7·90	5·65	5·52
Sulphates. Total	3·18	3·72	4·10	4·11	3·50	3·72
Sulphates. Alkaline (A)	2·97	3·52	3·85	3·86	3·31	3·50
Sulphates. Aromatic (B)	0·21	0·20	0·25	0·25	0·19	0·22
Sulphates. Ratio A : B	14·1 : 1	17·6 : 1	15·4 : 1	15·4 : 1	17·4 : 1	16·0 : 1

Fæces: Quantitative Analysis

Date, March 1905	16	17	18	Average
No. of motions	1	1	1	5 days.
Quantity	101	132	203	87
Water per cent.	66·60	69·22	80·08	71·97
Nitrogen	1·42	1·71	1·70	0·97
Fat	5·48	6·60	6·57	3·73
Absorbed nitrogen per cent.	—	—	—	95·41
,, fat per cent.	—	—	—	96·33

The urine analysis in this case (Table L.) showed an increased quantity of urobilin and indican. The aromatic sulphates are seen to be increased, and since this patient suffered from headaches, &c., there was evidently auto-intoxication. Microscopically, the presence of calcium oxalate crystals gave credence to the idea of the digestion not being quite normal, but otherwise, the qualitative analysis showed nothing abnormal. During the period of five days the patient took 25·93 Calories per kilo, and the weight remained more or less constant. The nitrogen output in the urine was fairly equal, and the quantity in the urine and fæces showed that the patient was practically on nitrogen equilibrium. On turning to the analysis of the fæces, it was found that the patient passed hard rolls composed of masses of scybala. The odour was very offensive only after the pill had been given, the first two motions being noted as of moderate odour. Chemically, mucus was found to be increased and mixed with the lumps, some of the scybala being coated with it. Albumen, blood, and bile were absent; the stools showed excess of urobilin by the perchloride of mercury test. Microscopically, vegetable cells, starch granules, some partially digested muscular fibres and a few fat drops could be recognised. The mucus contained a few epithelial cells and some leucocytes were seen, cholesterin crystals being also present.

The quantitative analysis of the fæces showed the first two motions, which occurred without a pill, to consist of 101 and 132 grams respectively, containing 66·60 and 60·22 per cent. of water. The stools contained 1·42 and 1·71 grams of nitrogen per diem, and 5·48 and 6·60 grams of fat respectively. The third stool (obtained after a pill had been given) consisted of 203 grams, and contained 80·08 per cent. of water; the quantity of nitrogen was 1·70 grams, and the quantity of fat 6·57 grams, so that the pill, although it increased the quantity of water, did not have any effect on the amount of nitrogen and fat excreted. The average output of nitrogen and fat, for the five days on which the patient was examined, corresponded with what one normally finds on this diet. The absorption of nitrogen was 95·41, and that of fat 96·33 per cent., which was about normal on this diet. The after-history of this case negatives carcinoma, and with regular bowel treatment, the constipation was cured, and he now feels perfectly well.

CHAPTER XXIV

INTESTINAL DYSPEPSIA

ALTHOUGH dyspepsia literally means disturbance of the peptic digestion, the expression "intestinal dyspepsia" has gradually crept in to describe those forms of indigestion which arise in the bowel from functional derangement leading to alterations in the succus entericus. In discussing diseases of the stomach, we have shown how simple functional changes in the secretion of the gastric juice can produce a varied group of symptoms, and it is not to be wondered at that alterations in such an important secretion as that of the succus entericus should cause symptoms of indigestion. Faber,[1] in a very able paper, has shown how various symptoms which used to be described as gastric can really arise from disturbance in the bowel itself. It must, however, be realised that our knowledge of the pathology of the succus entericus is extremely limited, and we can only now generalise, hoping that, in the future, problems will be unravelled by careful analyses of the stools, just as they are now being solved by the stomach-tube in gastric pathology.

Intestinal dyspepsia, for all clinical purposes, can be divided into two classes: (1) Excessive fermentation of the carbohydrates in the bowel, and (2) Excessive putrefaction of the proteid in the bowel.

Excessive Fermentation of the Carbohydrates in the Bowel.—Schmidt and Strasburger[2] have specially investigated the excessive fermentation of the carbohydrates which occurs in the alimentary canal in cases of intestinal dyspepsia. If, on employing Schmidt's fermentation tube, one obtains on the test diet more than one-third volume of gas from the fæces in twenty-four hours, one may consider that there is carbohydrate fermentation; and at the

[1] Archiv. *Verdauungskrankheiten*, vol. viii. p. 15.
[2] *Die Fæces des Menschen*, p. 198.

same time, the fæces themselves become more acid during the process of fermentation by the development of lactic and butyric acids, &c.

We will now describe a case which seems suitable for demonstration of the intestinal dyspepia due to excessive fermentation.

A male, aged thirty, when over-worked or worried, was subject to periodical attacks of pain in the bowels, coming on in the middle of the night, the patient having suffered in the same way three years previously. Taking hot water or food had no influence on the pain, which he described as not a true gripe, but rather discomfort with flatulency and gurgling going on in the intestines. There was some tendency to sluggishness of the bowels, though no marked constipation.

During a period of four days, analyses were carried out on a mixed diet with the addition of milk.

The qualitative analysis of the urine showed a slight increase of indican; some few uric acid and calcium oxalate crystals were found microscopically. On boiling, phosphates were precipitated in the urine; at the same time, on referring to Table LI., it will be seen that there was no real increase in the daily quantity of phosphates. The quantitative analysis of the urine showed that it was almost normal, the aromatic sulphates not being increased.

The qualitative analysis of the fæces may be now described. The first charcoal appeared in 26 hours, and the second charcoal, which was given on the fifth day, did not appear until 51 hours later, in spite of there having been a daily action of the bowels.

The colour of the fæces except when charcoal was present was, throughout the period, dark brown or greenish brown. The consistency was formed rolls with some small lumps which could hardly be called scybala. The odour was noted to be offensive throughout.

Examination of the fæces showed an excess of mucus both on inspection and when rubbed up with water.

The watery extract of the fæces gave a distinct albumen reaction.

Blood and bile were absent in all the motions.

The urobilin appeared to be increased in spite of the fact that the urine analysis showed no increase of urobilin.

On microscopic examination of the fæces, some partially digested muscular fibres, a few starch granules and fat drops, together with some remnants of vegetable cells were found. There were a few epithelial cells in the mucus, but not sufficient to allow of a diagnosis of intestinal catarrh.

TABLE LI.—DISEASE—INTESTINAL DYSPEPSIA

DIET: Mixed + milk, containing 18·72 grams nitrogen, 100·86 grams fat, 126·24 grams carbohydrates, 1839·60 Calories, 2130 c.c. fluid

Date, March 1905 . .	5	6	7	8	Average.
Weight in kilos . .	70·76	70·88	71·10	70·43	70·79
Calories per kilo . .	26·60	25·95	25·87	26·12	25·99
Urine: Quantitative Analysis					
Quantity . . .	960	1520	1240	1420	1231
Specific gravity . .	1022	1024	1023	1023	1023
Nitrogen . . .	—	—	18·97	14·64	17·80
Urea	24·56	46·36	34·97	27·12	28·35
Uric acid . . .	0·18	0·78	0·76	0·28	0·50
Ammonia . . .	0·04	0·41	0·32	0·38	0·29
Phosphates (P_2O_5) . .	2·14	4·59	3·41	2·69	3·21
Chlorides . . .	4·80	7·60	3·50	5·25	5·29
Sulphates: Total . . .	2·37	3·92	3·76	2·56	3·15
Sulphates: Alkaline (A) . .	2·24	3·63	3·56	2·40	2·96
Sulphates: Aromatic (B) . .	0·13	0·29	0·20	0·16	0·19
Sulphates: Ratio A : B . .	17·2 : 1	13·6 : 1	17.8 : 1	15·0 : 1	16·1 : 1
Fæces: Quantitative Analysis					
Date, March 1905 .	6	7	8	9	Average
No. of motions . .	1	1	1	1	4 days.
Quantity . . .	122	36	89	117	91
Water per cent. . .	72·73	71·41	71·41	75·16	72·68
Nitrogen . . .	1·43	0·44	1·09	1·25	1·05
Fat	5·22	1·62	4·00	4·57	3·85
Absorbed nitrogen p. c. .	—	—	—	—	94·39
" fat per cent. .	—	—	—	—	96·18

Quantitative Analysis of the Fæces.—As already mentioned, the patient passed a motion each day, and it will be seen that the daily average quantity of fæces was 91 grams, containing 72·68 per cent. of water. The quantity of nitrogen excreted per diem was 1·05 grams, and of fat 3·85 grams so that the daily average absorption of nitrogen and fat respectively was 94·39 and 96·18 per cent. Thus we see that in this case there was no indication of want of absorption or marked organic disease of the intestine.

On Schmidt's diet, the motions were of a light yellowish-brown colour, principally rolls, although some soft scybala were massed together in irregular lumps. There was apparently no marked increase of mucus, and the chemical analysis corresponded with that on the mixed diet. On the other hand, with Schmidt's fermentation tube, five grams of fæces yielded no less than two-

TABLE LII.—DISEASE—INTESTINAL DYSPEPSIA

DIET: Mixed, containing 16·88 grams nitrogen, 77·10 grams fat, 127·97 grams carbohydrates, 1676·39 Calories, 1270 c.c. fluid

Date, March 1903	15	16	17	18	19	Average
Weight in kilos	73·80	73·80	73·88	73·80	73·91	73·84
Calories per kilo	22·70	22·70	22·69	22·70	22·68	22·69
Urine: Quantitative Analysis						
Quantity	1460	1440	1400	1460	1290	1410
Specific gravity	1021	1021	1018	1020	1021	1020
Nitrogen	16·35	16·56	16·94	17·23	18·83	17·18
Urea	34·16	34·85	33·09	34·75	33·93	34·15
Uric acid	0·90	0·90	0·91	0·92	0·97	0·92
Ammonia	0·65	0·63	0·29	0·60	0·63	0·56
Phosphates (P_2O_5)	2·57	2·63	2·51	2·54	2·49	2·55
Chlorides	7·33	5·33	7·00	8·03	5·81	6·70
Sulphates: Total	5·71	4·13	3·42	3·62	3·88	4·15
Sulphates: Alkaline (A)	5·49	3·11	3·17	3·35	3·61	3·90
Sulphates: Aromatic (B)	0·22	0·22	0·25	0·27	0·27	0·25
Sulphates: Ratio A : B	25·0 : 1	17·8 : 1	12·7 : 1	12·4 : 1	13·4 : 1	15·6 : 1
Fæces: Quantitative Analysis						
Date, March 1903	15	17	19	20	21	Average
No. of motions	2	1	1	1	1	5 days.
Quantity	333	66	52	88	68	121
Water per cent.	83·36	73·39	69·39	71·36	69·12	73·32
Nitrogen	1·88	0·60	0·54	0·86	0·71	0·92
Fat	9·12	2·89	2·62	4·15	3·46	4·45
Absorbed nitrogen p.c.	—	—	—	—	—	94·55
,, fat per cent.	—	—	—	—	—	94·23

thirds volume of gas, and on some occasions, even more. At the fermentation test, the reaction was found to have become markedly acid. It would, therefore, appear that this case can well be put down as more or less typical of intestinal dyspepsia, due to fermentation of the carbohydrates.

Intestinal Dyspepsia Due to Excessive Putrefraction of the Proteid in the Bowel.—A male, aged thirty-six, suffered from periodical attacks of marked depression accompanied by a certain amount of pain in the loins and shoulders. He was very nervous, complained of frequent headaches, and said he had suffered for years from so-called nervous dyspepsia, for which he had been treated two years previously by Leube. The bowels acted irregularly, tending to constipation, though he often suffered from attacks of diarrhœa of a few days' duration. The patient was put on an ordinary mixed diet, and a five days' analysis carried out.

The qualitative analysis of the urine showed increase in urobilin and indican, otherwise nothing special was noted. The quantitative urine analysis merely showed a tendency to increase in the quantity of aromatic sulphates.

The qualitative analysis of the fæces (Table LII.) showed that the first charcoal appeared in six hours and twenty-five minutes after its administration, and it is quite possible that in this case, the patient being distinctly neurotic, the increased peristalsis was purely psychological. On the first day, the patient passed two motions, and on the other four days, one motion daily. The second charcoal took forty-nine hours and fifteen minutes to appear in the fæces. The motions on the five days of analysis were always formed; on the first day they are described as "soft formed with some liquid," and on the last as "formed rolls mixed with scybala massed together in the form of sheeps' motions." The colour, except when charcoal was mixed with the stool, was dark brown or greenish brown. There was a good deal of mucus mixed up in the stools, and the odour was throughout very offensive.

The chemical examination of the fæces showed an excess of mucus in all the motions.

Blood and bile were absent throughout.

Urobilin was present in excess.

The microscopic examination showed nothing remarkable, and the number of epithelial cells, mixed up with the mucus, was so small that this case could not be put down as catarrh of the bowels.

The quantitative analysis of the fæces shows a daily excretion varying from 52 to 333 grams. On the first day when there was increased peristalsis, the percentage of water was 83·36, while it is seen on the other days to vary from 69 to 73 per cent. only, the daily average of fæces being 121 grams, containing 73·32 per cent. of water. The nitrogen in the fæces showed an average of 0·92 grams, and the fat an average of 4·45 grams. The absorption of nitrogen was, therefore, normal, though the absorption of fat showed a tendency to decrease, being only 94·23 per cent.

During another period, Schmidt's diet was given, and the motions examined by Schmidt's fermentation-tubes. In this case, the fermentation test showed a volume of gas of a little over one-third; at the same time, a neutral motion, on one occasion, became alkaline during the process of fermentation, and, on the other occasions, the alkalinity which was present at the commencement seemed to increase.

In considering the urine in this case, we find that there is an increase of urobilin and indican, together with an increased quantity of aromatic sulphates.

With regard to odour, the motions were extremely foul, and contained a large amount of indol, phenol, and skatol. The increased intestinal putrefaction in this case is seen, however, not to be accompanied by decrease in the absorption of proteid as indicated by ordinary analysis. At the same time, we must remember that in this case there was an excessive quantity of mucus, and it has been generally demonstrated that increased intestinal putrefaction is more apt to occur in cases where there is excess of mucus, blood, or pus in the bowel than in cases where the increased proteid of the stool is due to deficient absorption.

The patient suffered from comparatively slight fermentation when compared with what one sees in corresponding cases of intestinal dyspepsia due to fermentation of the carbohydrates. This is owing to the fact that indol, phenol, and skatol do not irritate the bowel, and cause increased peristalsis, or so large an increase of gas, as is the case in fermentation of the carbohydrates, where lactic and butyric acids act as irritants on the mucous membrane of the bowel.

CHAPTER XXV

INTESTINAL CATARRH, ACUTE AND CHRONIC; ENTERITIS CROUPOSA

Catarrh of the bowels would appear to be a more common disease than catarrh of the stomach; at the same time, it is doubtful whether it is as common as is generally supposed, since certain cases of diarrhœa from nervous or other causes are undoubtedly popularly called catarrh of the bowel, when, as a matter of fact, there is no organic change in the intestine. It seems that enteritis, when a more systematic examination of the fæces is undertaken, will be found not to play so important a *rôle* in the pathology of bowel disease, just as gastric catarrh, since the introduction of the stomach-tube, is often found not to be present, the symptoms being due to functional derangement of the stomach only.

Catarrh of the bowels may be produced by various causes. Chemical substances in some cases directly irritate the mucous membrane of the intestine, setting up a true catarrh, while in other cases certain articles of food taken in excessive quantity—so that the digestive functions are not sufficient to carry out the proper preparation of the food—irritate the mucous membrane of the bowel, either by reason of the bulk of the food or the products of decomposition. In other cases again, the food itself may be tainted, and directly irritate the mucous membrane of both the stomach and bowel, setting up a gastro-intestinal catarrh.

Certain bacteria may undoubtedly set up a true enteritis, *i.e.*, cholera, typhoid, and probably, in some cases, the bacillus coli themselves. In certain individuals, cold is apt to set up true catarrh of the bowels just as in others cold sets up catarrh of the respiratory tract.

Since it is only our intention here to discuss the chemical changes produced in the fæces by the process of catarrh, it is unnecessary for us to divide it into the various sub-divisions according to the cause of the enteritis; it will suffice for our purposes to divide it into two forms, acute and chronic catarrh, treating colitis separately.

ACUTE CATARRH OF THE BOWELS

Acute catarrh of the bowels, unless it is very limited in extent, is practically always accompanied by a certain degree of diarrhœa; this is partly due to the increased quantity of water present in the fæces, and partly to the excessive amount of mucus thrown off from the inflamed bowel. It has to be remembered that the consistency and not the frequency of the stools must be designated as diarrhœa. The motions will vary in frequency from 1 to 20 per day. In cases where the catarrh involves both the small and the large intestine, there is a tendency to frequency of motions. When the catarrh is limited to the large intestine, especially the lower end of it, the motions may be as many as 20 or more per diem, while on the other hand, in cases of intestinal catarrh limited to the small intestine, it is not at all unusual to have only one motion passed daily. The first motion may be of a semi-solid nature, quickly followed by more or less liquid stools, the later motions tending to be frothy and extremely slimy. It is not at all uncommon to find amongst the liquid stools a certain quantity of scybala, which are really the retained motions of previous days.

The colour of the fæces in adults varies from light brown to a greenish colour. An absolutely green colour in adults is only present in rare cases, and is always due to the presence of an increased quantity of biliverdin. In children, on the other hand, it is quite common to find green stools even in the slighter cases of catarrh, and this may be due either to biliverdin or the products of bacteria themselves. The odour of the fæces varies very much according to the cause of the catarrh and the frequency of the motions. The first motions in acute catarrh are, as a rule, very offensive, but if there are numerous motions with excessive transudation into the bowel, causing a washing-out of the bacteria and their products from the large intestine, the odour may become practically inoffensive. Where the motions are less frequent, so that the bacteria have time to multiply in the excessive exudation, the odour is extremely offensive. In cases of catarrh of the bowel on a milk diet, one finds an acid odour owing to the excessive quantities of lactic, butyric, and acetic acids.

We may now consider a typical case of catarrh of the bowels, using it as an illustration of what one may expect to find in ordinary cases of acute catarrh of the bowel, not affecting the large intestine.

A male, aged twenty-three, had periodical attacks of diarrhœa set up either by chill or slight errors in diet, and often accompanied by slight fever.

The qualitative analysis of the urine showed an increase of indican and urobilin, but nothing else of note.

TABLE LIII.—DISEASE—ACUTE CATARRH OF THE BOWELS

DIET: Mixed, containing 18·36 grams nitrogen, 114·44 grams fat, 126·71 grams carbohydrates, 2051·49 Calories, 1510 c.c. fluid

Date, October 1904	6	7	8	9	Average.
Weight in kilos	66·37	66·37	67·50	67·50	66·94
Calories per kilo	30·91	30·91	30·54	30·54	30·73
Urine: Quantitative Analysis					
Quantity	1300	1290	1430	1490	13·78
Specific gravity	1026	1024	1023	1022	1024
Nitrogen	18·75	19·35	22·58	21·38	20·49
Urea	39·52	37·73	39·04	38·89	38·80
Uric acid	0·35	0·70	0·88	0·86	0·70
Ammonia	0·72	0·64	0·60	0·17	0·53
Phosphates (P_2O_5)	3·02	2·91	3·13	3·28	3·09
Chlorides	7·41	7·65	8·48	9·37	8·23
Sulphates: Total	3·76	3·56	3·42	4·07	3·70
Sulphates: Alkaline (A)	3·63	3·37	3·23	3·83	3·51
Sulphates: Aromatic (B)	0·13	0·19	0·19	0·24	0·19
Sulphates: Ratio A : B	27·9 : 1	17·7 : 1	17·0 : 1	16·0 : 1	19·7 : 1
Fæces: Quantitative Analysis					
Date, October 1904	6	7	8	9	Average
No. of motions	1	1	1	2	4 days.
Quantity	211	92	42	65	102
Water per cent.	84·88	77·53	70·98	76·46	77·46
Nitrogen	1·69	1·10	0·65	0·81	1·06
Fat	5·48	3·59	2·09	2·63	3·45
Absorbed nitrogen p.c.	—	—	—	—	94·23
„ fat per cent.	—	—	—	—	96·99

The quantitative analysis of the urine (Table LIII.), which was carried out during a slight febrile attack, shows an excess in the quantity of nitrogen eliminated above that taken in the diet, the uric acid being also increased.

The analysis of the fæces shows that the first charcoal appeared two hours after its administration ; the second charcoal, which was given on the fifth day appearing four hours later. During the four days of observation, the patient passed one motion daily, except on one occasion, when there were two motions. They consisted of soft, slimy paste, occasionally tending to the formation of soft rolls, but no scybala were present. The motions appeared frothy from excessive formation of gas, and the odour was extremely offensive throughout.

Chemical Analysis of the Fæces.—On inspection of the stools, it was at once seen that mucus was present in large excess. In all cases of catarrh of the bowel one finds this excess of mucus, and in this case, on spreading some of the fæces on a plate for thorough examination, the mucus was found to be intimately mixed with the fæces; and in some of the specimens, gelatinous lumps or strips of mucus were found.

The watery extract of the fæces gave a marked albumen reaction.

At no time was blood found to be present, and this would appear to be the rule in the majority of cases of acute catarrh. In some few cases, very minute quantities of blood may be noticed, and when this occurs, some of it is usually mixed with the mucus.

This case gave no reaction for bile pigments, though in some cases of catarrh of the bowel with frequent motions one may find even in adults a distinct bile reaction, and, in many cases, the mucus is found to be stained by bile pigment.

The examination of the fæces for urobilin showed a marked excess, and this has been our general experience.

Microscopically, the fæces showed partially digested muscular fibres, together with vegetable cells, a few starch granules and fat drops. The microscopic examination of the mucus showed that it contained numerous epithelial cells, together with a few isolated leucocytes ; in all specimens examined, the epithelial cells were prominent. If one is to diagnose catarrh of the bowel, it is essential that one should find numerous epithelial cells mixed up with the mucus, as the mere presence of mucus is not in itself sufficient evidence that there is true catarrh going on. If ulceration is not also present, very few leucocytes will be found.

The quantitative analysis of the fæces showed that in spite of their being so soft, and apparently of such a watery consistency, the actual quantity of water was not increased to any great extent. Only on the first day was it as much as 84·88 per cent., the average for the four days being 77·46 per cent. The quantity of nitrogen present in the fæces averaged during the four days 1·06 grams, and the fat during the same period averaged 3·45 grams. The absorption of nitrogen was 94·23 per cent. (being a slight decrease), while that of fat was 96·99 per cent. It would appear that this is, as already stated, a more or less typical case of catarrh of the bowel, in which the large intestine is not involved to any marked extent, the important point being the fact that the motions did not contain any marked increase of water although the increased quantity of mucus very considerably altered their consistency from the normal standard ; and it is also to be noted that the frequency was not increased, whereas in many cases one finds a distinctly increased number of motions. But, as we have already remarked, this is largely dependent upon the extent to which the lower end of the large intestine is involved.

CHRONIC CATARRH OF THE BOWELS

The difference between acute and chronic catarrh of the bowels is one chiefly of degree, and many cases can be described as acute catarrh, verging on sub-acute, and sub-acute verging again on chronic, without its being possible to say definitely what distinguishes one from the other. Generally speaking, one may consider that in acute catarrh there is a tendency to diarrhœa, while in chronic catarrh there is more apt to be a tendency to constipation. The latter varies very much ; sometimes there may be two or three days constipation followed by more or less diarrhœa, while in other cases one gets diarrhœa motions of a semi-solid consistency alternating with solid motions. There is a tendency in chronic catarrh for the quantity of fæces to be larger than normal, and considering the tendency to constipation, this is remarkable, though it may be partly explained by the increased quantity of mucus which accompanies the chronic catarrhal process.

The condition of the fæces in chronic catarrh can well be illustrated by taking a case and founding our description on what was found in this individual.

TABLE LIV.—DISEASE—CHRONIC CATARRH OF THE BOWELS

DIET: Mixed + milk, containing 22·15 grams nitrogen, 83·79 grams fat, 102·59 grams carbohydrates, 1768·43 Calories, 1740 c.c. fluid

Date, May 1904	17	18	19	20	Average.
Weight in kilos	81·73	81·90	81·56	82·13	81·78
Calories per kilo	21·64	21·60	21·68	21·53	21·61
Urine: Quantitative Analysis					
Quantity	1120	1920	1270	1340	1413
Specific gravity	1020	1022	1024	1022	1022
Nitrogen	14·90	29·76	24·10	24·12	23·72
Urea	27·55	62·21	48·01	49·31	46·77
Uric acid	0·73	1·11	1·00	0·98	0·96
Ammonia	0·16	0·84	0·85	0·67	0·63
Phosphates (P_2O_5)	1·95	3·03	3·59	2·87	2·86
Chlorides	4·59	7·10	5·21	5·50	5·60
Sulphates: Total	2·73	5·97	4·48	4·42	4·40
Sulphates: Alkaline (A)	2·53	5·57	4·23	4·14	4·12
Sulphates: Aromatic (B)	0·20	0·40	0·25	0·28	0·28
Sulphates: Ratio A : B	12·7 : 1	14·0 : 1	16·9 : 1	14·8 : 1	14·7 : 1
Fæces: Quantitative Analysis					
Date, May 1904		21	23	25	Average
No. of motions		1	2	1	4 days.
Quantity		261	343	138	186
Water per cent.		70·84	79·61	86·86	79·10
Nitrogen		3·73	3·43	0·89	2·01
Fat		9·02	8·29	2·15	4·87
Absorbed nitrogen per cent.		—	—	—	90·93
,, fat per cent.		—	—	—	94·24

A male, aged thirty-six, had periodically indulged in alcohol to excess. He was said to have frequent attacks of indigestion together with constipation, this condition having lasted for some years. The patient passed a motion regularly for several days and then, for no apparent reason, he would become constipated. He had been in the habit of taking drugs when constipated for more than two days, so as to avoid a longer period of constipation.

During the time of observation, a four days' analysis was carried out on a mixed diet with the addition of milk. The qualitative analysis of the urine showed an increase in the quantity of indican and urobilin, but no sugar or albumen; nothing else of interest was noted.

The quantitative analysis of the urine (Table LIV.) showed, comparatively speaking, a large quantity of urea, and the nitrogen in the urine was slightly in excess of that given in the diet, the total daily excretion of uric acid being high, and the aromatic sulphates increased.

The examination of the fæces during the period showed that the first charcoal appeared in 95 hours 45 minutes after its administration, and the charcoal given on the fifth day appeared in 51 hours, so that we have in this individual a decided tendency to delayed motor-power of the alimentary tract, this being the usual condition found in chronic catarrh of the bowels. The patient, during the four days of analysis, passed motions on alternate days, there being on the second alternate day two stools. The fæces consisted of formed rolls with a tendency to scybala matted together like sheeps' motions, while, on one day, the stool was unformed, and of a pasty consistency. The colour was dark greenish, and the odour throughout the period was very offensive. In simple chronic catarrh, one nearly always finds very offensive motions, and they are always more offensive than those of simple constipation.

The chemical examination of the fæces showed a marked excess of mucus, which on careful inspection was found to be intimately mixed with the fæces. Albumen was found to be present in the watery extract of the fæces, this being what we have found in all the cases of chronic catarrh which we have investigated. Neither blood nor bile was present, and this would appear to be the rule in such cases. The reaction of all the motions passed was alkaline, and the addition of perchloride of mercury solution to the fæces showed a very marked excess in the quantity of urobilin.

In cases where the catarrh involves the large as well as the small intestine, fragments of muscular fibres are found, by microscopic examination, to be more numerous than usual. When, however, connective tissue is also present, it shows, according to Schmidt, that the stomach is implicated. Numerous vegetable cells were noticed in this case, and fat drops were also present. The presence of an increased quantity of fat in the stools is not at all uncommon in chronic catarrh of the bowels. Crystals of ammonium magnesium phosphate and calcium salts of bile acids were observed, and numerous epithelial cells were intimately mixed with the mucus, but no leucocytes could be found.

The quantitative analysis of the fæces showed that on one day no less than 343 grams were passed, while the average for the four days was 186 grams, this being higher than normal on such a diet. The quantity of water present in the fæces was comparatively speaking, small, the average output being 79·10 per cent., thus making the large quantity of fæces the more remarkable. The nitrogen in the fæces averaged no less than 2·01 grams per diem, and the fat 4·87 grams. We see, therefore, a very marked diminution in the quantity of nitrogen absorbed, 90·93 per cent., while there was also a diminution in the absorption of fat, 94·24 per cent.

As already stated, this case can be taken as a general type of chronic catarrh of the bowel. At the same time, we must remember that analyses vary very much, and, in some cases, the absorption of both nitrogen and fat is found to be almost normal, while in the majority of cases it is diminished, often markedly so. In one case of catarrh of the bowels occurring in a possibly tubercular individual, who passed from 3 to 4 motions per diem, we found the absorption of nitrogen to be 66·40, and that of fat 82·50 per cent.

ENTERITIS CROUPOSA

The pathological condition recognised as enteritis crouposa or, as it is more often called, diphtheritic enteritis, is a rare disease. It is certainly extremely rare when diphtheria bacilli themselves are the cause of the condition, and to avoid misapprehension it would appear to be better to call it enteritis crouposa except when the Loeffler bacillus is the cause of the disease.

This condition is met with in cases of mercurial poisoning, either surgical or medical, and it seems especially to occur in people who are run down from any cause. Of late years, it has been not infrequently found where serous cavities have been washed out with perchloride of mercury.

In various infectious diseases, such as pneumonia, general septicæmia, scarlatina and smallpox, it is not unusual to find croupous enteritis. The pathological condition of dysentery is also included in this group.

The fæces will be found to be passed more frequently than usual; there is, as a rule, a good deal of tenesmus, and the motions are extremely watery.

The fæces will be found to be mixed with mucus, blood, and pus; in fact, they may consist of the latter material alone, and not uncommonly they contain shreds of tissue.

Under the heading of "blennorrhœa intestinalis," a group of cases may be classed, which are more chronic than the ordinary enteritis crouposa; as seen in tubercular or carcinomatous patients, or other cachectic individuals, the liquid motions are grey or almost white, and appear to be nothing but pus, mucus, and water.

It must be especially noted, as pointed out by Nothnagel, that purulent fæces are not found in proper catarrh of the intestine, but merely in the croupous form of inflammation of the bowel. Unfortunately, we are unable to give any metabolic analyses of the condition of enteritis crouposa.

CHAPTER XXVI

COLITIS—MUCUS, ULCERATIVE (ACUTE AND CHRONIC) AND MEMBRANOUS

Of late years, colitis has been especially brought to the notice of medical men as a disease *sui generis* and for this reason we consider it advisable to discuss it separately from catarrh. The pathological condition of the bowels in true colitis is of a very varied nature. In some cases where the clinical symptoms have been characteristic, the autopsy reveals very limited changes in the intestines. In describing the chemical conditions found in colitis, it is as well for us to make three sub-divisions of the disease : (*a*) Mucous Colitis. (*b*) Ulcerative Colitis (acute and chronic). (*c*) Membranous Colitis. The demarcation line between one and the other may, in some cases, be very narrow.

(*a*) MUCUS COLITIS

The form of colitis most frequently met with in ordinary practice is probably mucus colitis. Its etiology varies very much in different cases, although we do not agree with Lockwood that it is generally consequent on appendicitis. A great number of cases undoubtedly follow appendicitis, but this fact does not necessarily imply that the appendicitis is responsible for the condition. It may rather be that the attention of the doctors had not been drawn to the fæces until the appendicitis had asserted itself. In fact, the case which we are using to illustrate mucus colitis is one of those in which mucus was never *noticed* in the motions until after an attack of appendicitis, followed by operation. Of course, we do not mean to imply that the removal of the appendix set up mucus colitis, but that the underlying pathological condition which caused the appendicitis was probably the same as that which caused the colitis to appear later, and that the removal of the offending appendix was not sufficient to hinder the progress of the colitis.

The etiology of mucus colitis is difficult to define, and pathologists incline to divide into three groups: (1) those who hold that mucus colitis is a purely nervous disease arising from nervous alterations in the secretions of the colon; (2) those who consider the condition to be one of organic disease, having a distinct anatomical pathology; (3) those who attribute the condition partly to nervous and partly to anatomical changes. It appears to us that pure hypersecretion of mucus, arising from imperfect nervous control of the secretions of the bowel in neurotic and hysterical individuals, is sufficient to explain the condition in many cases.

The symptoms occurring in mucus colitis vary very considerably, and, in some cases, one gets a bizarre picture, the general weakness and lassitude of the patient, and the degree of wasting and malnutrition evinced being altogether out of proportion to the amount of nourishment taken, and further, to the amount of absorption shown by metabolism analysis. On the other hand, there are cases in which a large amount of mucus is discharged by the bowel, and where the general symptoms are so little marked that the mucus colitis is only discovered by accident. The ordinary signs of the condition, when looked for in these cases, are tenderness in various parts of the colon (ascending or descending, or more rarely the transverse), together with a certain amount of rigidity of the muscles over the tender area.

In describing the chemical conditions found in mucus colitis, we will again take one case as an example, and base our description on this.

A lady, aged thirty-six, who was distinctly neurotic, though in no way an invalid, and who was leading an ordinary society life, had always fussed about her general condition, and had been in the habit of frequently examining her motions. She was first seen in 1900 for indigestion with a tendency to constipation, though the latter condition was not very marked. There was no mucus present at that time. In 1903 she had an attack of appendicitis, for which the appendix was removed. Some time afterwards, when entirely recovered from the appendicitis, she first noticed the presence of mucus in her motions; eighteen months later, she complained of pain along the whole course of the ascending and transverse colon, and general lassitude, having great difficulty in getting through her ordinary engagements. She stated that for the last year or more she had noticed mucus in more or less large quantities in her motions, and that she had periodical febrile attacks. The patient was put on an ordinary mixed diet with the addition of milk, and analyses carried out.

The qualitative analysis of the urine showed an increase of indican, but no marked increase of urobilin, the urine being otherwise normal except for the presence of some calcium oxalate crystals.

TABLE LV.—DISEASE—MUCUS COLITIS

DIET: Mixed + milk, containing 18·92 grams nitrogen, 88·18 grams fat 108·00 grams carbohydrates, 1777·69 Calories, 1680 c.c. fluid

Date, March 1905	2	3	4	Average.
Weight in kilos	48·60	48·60	48·60	48·60
Calories per kilo	36·58	36·58	36·58	36·58
Urine: Quantitative Analysis				
Quantity	1400	1370	1150	1307
Specific gravity	1016	1016	1023	1018
Nitrogen	11·48	15·21	18·06	14·92
Urea	18·76	24·52	32·13	25·10
Uric acid	0·11	0·33	0·07	0·17
Ammonia	0·18	0·26	0·52	0·32
Phosphates (P_2O_5)	1·62	2·14	2·44	2·07
Chlorides	5·30	5·62	5·18	5·37
Sulphates: Total	2·34	3·06	3·36	2·92
Sulphates: Alkaline (A)	2·26	2·91	3·20	2·79
Sulphates: Aromatic (B)	0·08	0·15	0·16	0·13
Sulphates: Ratio A : B	28·3 : 1	19·4 : 1	20·0 : 1	21·5 : 1

Fæces: Quantitative Analysis

Date, March 1905.	3	4	5	6	Average 3 days.
No. of motions	1	1	1	1	
Quantity	106	115	65	37	108
Water per cent.	86·99	78·21	66·95	72·75	76·23
Nitrogen	0·81	1·48	1·27	0·59	1·38
Fat	1·81	3·28	2·81	1·32	3·07
Absorbed nitrogen p.c.	—	—	—	—	92·71
„ fat per cent.	—	—	—	—	96·52

The quantitative analysis of the urine showed, as will be seen in Table LV., a tendency to decrease in the quantity of nitrogen ;

unfortunately, however, the analysis was begun immediately the patient was put on the diet instead of three or four days later, and hence the small quantity of nitrogen on the first day (11·48 grams). In spite of the patient taking 36·58 Calories per kilo, there was no gain of weight during the period of analysis and, as will be shown later, this could not be entirely explained by the want of absorption.

The quantitative analysis of the fæces showed the first charcoal to appear in 25½ hours after its administration by the mouth, the second charcoal taking 37 hours to appear.

During the three days of analysis, the patient passed one motion daily, consisting of unformed paste of a brownish green colour and with an extremely offensive odour. Some of the motions tended to consist of formed rolls, but, as a rule, they were quite pultaceous.

In a certain number of cases of colitis, one sees a tendency to diarrhœa of a mild type, the charcoal appearing in 6 to 8 hours after its administration. In such cases the patient may have one or more motions daily, some of them consisting of almost pure mucus; in other cases, there is a distinct tendency to delay in the appearance of the charcoal in the fæces, varying from 48 to 150 hours. These patients may pass more or less solid motions mixed with mucus in varying amounts, and as a rule, the motion is of the normal sausage shape with an occasional tendency to scybala, the sausage motion being, however, always much softer than normal. It would appear that the tendency to an excessively putrid odour is not so great as in simple catarrh.

The chemical examination in the case we are discussing showed a very marked excess of mucus, it being not only intimately mixed with the fæces, but also in separate masses in the pultaceous motion. The quantity of mucus varied very much from day to day, the porridge-like motion being very slimy, and adhering to the sides of the vessel. The mucus itself was of a yellowish colour, occasionally tending to be streaky, though there was never any appearance of membranous casts.

In mucus colitis, as we have previously said, one finds large quantities of mucus separate from the motion, as well as some intimately mixed with the ordinary stool. The mucus, as a rule, is shiny white, and not uncommonly it has the appearance of boiled sago. The white slimy mucus varies so much in its consistency and quantity that one sometimes finds it difficult to distinguish mucus colitis from the condition which we shall later describe as membranous colitis.

The watery extract of the fæces in this case showed no albumen reaction; in some cases, however, of mucus colitis, one finds a distinct albumen reaction in the watery extract of the fæces, although—unlike catarrh of the bowels—it is not at all common.

Blood and bile were absent from all the motions, and this would appear to be the universal rule in cases of simple mucus colitis.

In the majority of cases of mucus colitis, the reaction for urobilin both in the fæces and urine is normal, while in catarrh of the bowel there is a tendency to increase of urobilin.

The microscopic examination showed some slight increase of muscular fibre, a few starch granules, and some fat drops, together with crystals of ammonium magnesium phosphate and calcium oxalate. The mucus under the microscope was seen to consist of transparent matter containing only a very few leucocytes, and here and there epithelial cells.

In mucus colitis, in addition to the quantity of mucus present in the stool, it is worthy of note that the mucus contains no large number of epithelial cells and leucocytes, thus at once distinguishing it from catarrh of the bowels.

The quantitative analysis of the fæces showed that during the four days when stools were passed (representing the three days' diet, as isolated by charcoal) the quantities varied from 37 to 115 grams, the average quantity of fæces per diem being 108 grams. The quantity of water present in the fæces is also seen to vary very considerably, from 66·95 to 86·99 per cent, the average being 76·23 per cent. The daily quantity of nitrogen fluctuated, the average being 1·38 grams, while the average quantity of fat per diem was 3·07 grams. The absorption of nitrogen was 92·71 per cent., showing a distinct tendency to decreased absorption, while that of fat was 96·52 per cent., which one may regard as normal. In many cases of mucus colitis, it would seem that the absorption tends to vary very little from the normal, although one finds variations which are difficult to explain. In this case, some of the increase in the quantity of nitrogen in the fæces can doubtless be explained by the increased quantity of mucus, so that the real absorption of the proteid taken in the diet was probably larger than would appear from the analysis.

ULCERATIVE COLITIS

Under the heading of ulcerative colitis, we have to include the two conditions, acute and chronic ulceration of the colon, the latter being very frequently met with in practice.

Acute Ulcerative Colitis.—Acute ulcerative colitis occurs both as tropical dysentery and sporadically. In true dysentery, the chemical analysis shows abundance of mucus, and one always obtains an albumen reaction, in addition to which peptone is generally present. Mucoid sanguinolent stools, containing numerous scybala, are frequently passed, the motions being accompanied by considerable pain and almost constant tenesmus. In severe cases, the discharge from the bowels becomes thinner and thinner, and of a more greenish colour, until at last one may obtain stools looking very much like the washings of meat. Microscopic examination of the motions reveals, together with numerous bacteria which we need not here describe, a large quantity of leucocytes and epithelial cells mixed up in the mucus.

Asylum dysentery has been very ably described by Mott and Durham.[1] The motions passed in this asylum dysentery very closely resemble those passed in ordinary dysentery, and the diagnosis has to be mainly based on the fact of having blood together with large amounts of mucus in the stools. In a really typical motion one may obtain, as in dysentery, a mixture of blood and mucus with very little else, though one generally finds some scybala. According to the degree of bowel affection, the proportions of liquid and solid fæcal material vary, so that in some cases one may have difficulty in recognising blood and mucus; careful examination will, however, generally reveal its presence. In some cases of asylum dysentery, it would appear that the patient does not continuously pass typical stools consisting of blood and slime; one gets on one day a typical stool, on the next, merely a loose motion, and on the third and fourth

[1] "Report on Colitis and Asylum Dysentery," May 1900, p. 15.

days a constipated motion ; but in the latter event, the motions will be coated with shreds of blood and patches of slime.

The mucus present in asylum dysentery is generally somewhat tenacious, and consists of a jelly-like material, translucent or slightly opaque ; the colour is whitish (except when blood is present to redden it), or it may have a greenish hue. Microscopically, numerous leucocytes will be found in the stools, and as a general rule, only a few epithelial cells.

Chronic Ulcerative Colitis.—Under the heading of chronic ulcerative colitis, one ought to include the various chronic ulcers which may occur in the large intestine as the result of tubercular or syphilitic disease, carcinoma, or any other morbid condition. The differential diagnosis between one and the other cannot, however, be arrived at by mere chemical analysis, so that we will content ourselves with describing the form which occurs in stercoral ulceration as a type of ulcerative colitis.

It would appear that scybala, from mere pressure or from the production of chemical irritants, are apt to cause ulceration of the large intestine. These scybala are especially inclined to be retained in the cæcum, hepatic, splenic or in the sigmoid flexure, and it is, therefore, in these positions that one most commonly finds stercoral ulceration.

Stercoral ulceration is very often accompanied by mucus colitis. That the scybala are the cause of the mucus colitis seems doubtful. It would appear much more likely that in those cases of mucus colitis in which there is chronic constipation or retention of scybala in certain positions, the scybala are the cause of the ulceration, and the mucus colitis is a mere accident.

The symptoms of chronic ulcerative colitis caused by fæcal retention vary very much according to the degree of constipation present, and also to the degree in which the individual reacts to the constipation. As we have already said, even slight constipation causes, in some people, very marked toxic symptoms.

In cases of stercoral ulceration we find by the charcoal method that there is, as a rule, great delay in the passage of charcoal along the alimentary tract. There are, however, cases in which the patient shows no delayed bowel action, and yet there is stercoral ulceration. In those cases where there is no absolute delay in the passage along the alimentary canal, one finds that, in spite of the bulk of the charcoal appearing at the end of twenty-four hours or so, some of it tends to be eliminated in the next two or three days. It would appear that in these cases, most of the fæces pass along the alimentary canal fairly rapidly, while certain scybala are retained in the sacculi of the large intestine for a longer period, some of these scybala setting up the ulceration.

We will now describe a case illustrative of the general condition. A male, aged thirty-four, had suffered from chronic constipation for many years; he complained of general abdominal discomfort and tenderness over the cæcum and sigmoid, pressure over other parts of the bowels revealing no tenderness.

TABLE LVI.—DISEASE—CHRONIC ULCERATIVE COLITIS

DIET: Mixed + milk, containing 21·57 grams nitrogen, 120·75 grams fat, 143·60 grams carbohydrates, 2522·97 Calories, 2070 c.c. fluid

Date, May 1903	3	4	5	6	7	8	Average.
Weight in kilos	59·85	59·79	59·85	61·09	60·41	60·13	60·12
Calories per kilo.	42·33	42·36	42·33	40·50	41·92	42·12	41·93
Urine: Quantitative Analysis							
Quantity	1820	1580	2140	1120	1840	2340	1807
Specific gravity	1016	1018	1017	1023	1014	1016	1017
Nitrogen	20·56	14·85	24·82	17·92	17·49	28·50	20·69
Urea	—	29·70	53·07	37·07	32·38	54·99	41·84
Uric acid	0·62	0·58	0·98	0·89	0·69	0·86	0·77
Ammonia	0·47	0·21	0·34	0·49	0·68	0·67	0·44
Phosphates (P_2O_5)	3·46	2·61	3·96	2·61	2·98	4·12	3·29
Chlorides	8·30	4·32	7·81	5·62	7·37	11·74	7·53
Sulphates. Total	3·94	2·42	5·00	3·41	3·67	5·76	4·03
Sulphates. Alkaline (A)	3·73	2·29	4·77	3·21	3·47	5·44	3·82
Sulphates. Aromatic (B)	0·21	0·13	0·23	0·20	0·20	0·32	0·21
Sulphates. Ratio A : B	17·7 : 1	17·6 : 1	20·7 : 1	16·0 : 1	17·3 : 1	17·0 : 1	18·2 : 1

Fæces: Quantitative Analysis

Date, May 1903	7	8	9	10	Average 6 days.
No. of motions	2	2	2	2	
Quantity	95	163	100	279	106
Water per cent.	63·23	65·16	65·45	76·70	67·64
Nitrogen	1·50	2·44	1·48	2·80	1·37
Fat	5·33	8·76	5·32	10·02	4·91
Absorbed nitrogen per cent.	—	—	—	—	93·65
,, fat per cent.	—	—	—	—	93·75

The patient was put on a mixed diet with the addition of milk, containing no less than 41·93 Calories per kilo, and on this diet he increased in weight. During a period of six days, metabolism analyses were carried out.

The qualitative analysis of the urine showed a marked increase in the quantity of indican, and an excess of uric acid crystals was noted in the sediment.

The quantitative analysis of the urine (Table LVI.) showed no marked increase in uric acid, although it was deposited in the urine. It is seen that the quantity of nitrogen daily excreted varied very considerably, the average, however, showing nitrogen equilibrium.

The analysis of the fæces showed the first charcoal to appear in 102 hours 55 minutes, while the second charcoal given on the seventh day appeared in 50 hours 15 minutes.

During the six days of analysis, motions corresponding to the diet were passed on only four days, there being two motions on each of these days. During the first three days on which the patient passed two motions daily, the quantities of each stool varied from 45 to 110 grams; on the last day when the motions were passed immediately after each other, the quantity was the largest noted, owing to the fact that a water enema was given (on account of there being some tenesmus from the retention of scybala in the rectum). As soon as the motion was obtained the water was poured off, the motion being analysed as free as possible from water. It was noticed that some charcoal-containing scybala appeared the day after the charcoal was first recognised in the fæces, that is to say, six days after its administration. The stool consisted of hard round lumps and rolls composed of numerous scybala massed together. At the same time, there were some separate scybala, and, on one occasion, the motion consisted entirely of separate scybala stuck together with thick mucus, stained with blood. Small coagula of blood were also found between the scybala. In addition to the mucus between the lumps, some of the scybala were coated with a layer of mucus as if they had been smeared over with vaseline, this layer of mucus being often distinctly tinged with blood. The odour was noted on all occasions to be extremely offensive.

The scybala in these cases of chronic ulcerative colitis are generally found to be more or less rounded, varying in size from a small bean to a large walnut. In cases where mucus colitis is present in addition to the stercoral colitis, one finds firm shellac-like mucus coating the scybala, and large quantities of slimy mucus of a bright yellow or dirty red colour are found to be mixed up in the stool.

The chemical examination of the fæces showed, as already described, a great excess of mucus. On breaking up the motions with water, only a little mucus was found mixed up in the scybala themselves. The watery extract of the fæces gave no albumen reaction, though in some cases of stercoral ulceration we get a distinct albumen reaction. In this case, small quantities of blood were found in clots adherent to the mucus or to the scybala. Bile was not found in any of the motions, and in no case of stercoral ulceration have we ever obtained a bile reaction.

In this case, perchloride of mercury showed a very feeble reaction for urobilin, although in the majority of cases of stercoral ulceration, we have found a tendency to an increased urobilin reaction.

The microscopic examination showed some partially digested muscular fibres, together with numerous vegetable cells, calcium salts of bile acids, and a few crystals of ammonium magnesium phosphate. The gelatinous mucus was found to contain numerous epithelial cells and leucocytes, and round some of the clots there appeared to be some fibrous tissue containing leucocytes; but distinct sloughs, which could be recognised as such, were not found.

The quantitative analysis of the fæces showed various quantities per diem; in spite of there being two motions on each of the four days belonging to the diet of six days, the daily quantity was not very large, and most of the delay in this case was probably present in the rectum itself, since a large quantity of fæces was obtained by giving a water enema, which hastened the expulsion of the fæces by two or three days. It is seen that the water varied from 63·23 to 65·45 per cent. during the first three days on which no enema was given. In spite of the fact that the water was poured off as soon as the motion was obtained, some must have remained behind, thus accounting for the increase of water in the fæces (to 76·70 per cent.), on the last day of analysis. The daily quantity of nitrogen fluctuated from 1·48 to 2·80 grams, the average for the six days being

1·37 grams, showing a slight increase of nitrogen on this diet. The quantity of fat is seen to be very large, varying from 5·32 to 10·02 grams, making a daily average of 4·91 grams. It is seen that the absorption of proteid was 93·65 per cent., while that of fat was 93·75 per cent., the absorption of both proteids and fat being below the normal.

MEMBRANOUS COLITIS

It has long been recognised that the passage of distinct membranes or casts occurs in certain neurotic individuals. Whitehead[1] gives a very full *résumé* of the literature on the subject, elating the observations of these casts by the early observers. It has been found in the few instances where autopsies have been carried out in individuals suffering from this membranous colitis that there were practically no anatomical changes to account for the condition. Between the periods of attack, the patient may suffer from no special intestinal troubles except possibly constipation. Colicky pains of more or less severity are followed in two or three days by the passage of membrane after which the patient feels very much better until the recurrence of a similar attack. In some cases, the stools consist almost entirely of shreds or tubular casts of membrane, which have a more or less fæcal odour; sometimes they are colourless when mixed with the fæces, and on washing they are always found to be grey or transparent white. The membranous material can take most fantastic forms, though careful examination generally reveals, on floating in water, an almost complete tube; at other times branched pieces of membrane are observed. Microscopic examination of the mass shows a glassy structure which on the addition of acetic acid gives a cloudy striation. One sometimes sees in the membrane numerous epithelial cells, while in other cases practically none are present. The membrane appears in some cases to be in distinct layers, between which it is not uncommon to find remains of undigested food or fæces. The membrane may contain numerous crystals of ammonium magnesium phosphate and cholesterin, and, occasionally, Charcot-Leyden crystals. The chemical analysis of the membrane when washed free from epithelial cells is found

1 *British Medical Journal*, 1871, February 11 and 18.

to consist principally of mucus. Leathes[1] considered that these casts were not mucus, since, when free from epithelial cells, they gave no reaction for proteid, and appeared to be composed of chitin derived from the carbohydrates. Fibrin has been described by Guttmann[2] as present in considerable quantities, though other observers appear to differ on this point, and to consider that the presence of fibrin is to be regarded as an exception. The appearance of the fæces in cases of pure membranous colitis practically differs in no way from that in ordinary constipation. At the same time, there are numerous cases of mucus colitis in which one periodically observes membranous casts. We have never been able to obtain any metabolism analyses during which the patient has suffered from the colicky pains and passed casts, although we have had cases under observation where membrane has been voided at various times. The most marked case which has come under our notice is that of a lady, aged forty-one, who had suffered from "weird" abdominal symptoms for some twelve years. On occasions, she would get girdle-like pains in the abdominal region which would become very tender, and on the same day or the day after, a membranous mass would be passed. Some of these membranes were described by the patient as 3 ft. long, though the specimens which came under our observation were never more than 2 ft. in length when floated out in water. The membranes on different occasions varied from 1 to 2 ft. in length, and were about 1½ in. in diameter. As a rule, they were extremely thin, although sometimes the walls were considerably thickened and distinct layers were evident. The membranes tended to be more or less colourless, although the white colour was sometimes masked by fæces. The tubes were, as a rule, passed separate from the fæces, or only contained very small quantities of fæcal matter. When washed free from fæces, they were perfectly colourless, and on no occasion did we find any staining from bile. No urobilin reaction was obtained except when contaminated by fæces, and blood was never present. The microscopic examination showed the membrane to consist of a colourless, structureless, glass-like substance containing a few leucocytes, and sometimes epithelial cells, which always showed marked fatty degeneration were found. In fresh specimens,

1 *Lancet*, 1905, vol. ii.
2 *Deutsch. Med. Wochenschr.*, 1887, No. 27.

ammonium magnesium phosphate crystals were never present, though, on some occasions, when the specimens were examined after some days' delay, numerous triple phosphates were found to be present. Charcot-Leyden crystals were never seen, although in old specimens cholesterin crystals were present. The chemical examination of the washed membrane gave a biuret reaction, and a pink colour with Millon's reagent. On the addition of acetic acid, the mass became more opaque, and on further addition of the acid, almost fluid. The membrane, after digestion with pepsin and hydrochloric acid, yielded a precipitate which contained phosphorus. On boiling with dilute acid and subsequent neutralisation, one obtained a reducing substance.

From these chemical tests, it is evident that the membranes consisted of a proteid containing both nucleo-albumen and true mucus.

In the intervals between the attacks, the patient was never well, suffering from chronic constipation alternating with attacks of diarrhœa, the chemical analysis showing that she had chronic mucus colitis. She described the occasional passage of liquid motions resembling "pigs' wash," with an extremely offensive odour and an acid smell, and of a dirty greyish-white colour. On several occasions we were able to make a chemical analysis of this patient's motions, which were found to vary greatly in quantity; the motor-power of the alimentary tract was also found to show considerable variations, the charcoal appearing on one occasion in 25½ hours, and on another in 73¾ hours. On other occasions when it was given, the time of its reappearance varied between these limits, but purgatives or enemata had to be given when there was considerable delay, as the patient became very nervous if the constipation was of long duration. The urine analysis showed nothing of note, and the fæces analyses always gave results which would lead one to diagnose mucus colitis. The absorption of nitrogen varied from 84·65 to 96·68 per cent., and the absorption of fat from 88·40 to 96·56 per cent. on a mixed diet during four different periods of metabolism analyses in the course of two years. The worst absorption occurred immediately after an attack of so-called "pigs' wash," when the motions were extremely offensive, and contained a large excess of mucus. On this occasion, some blood was found mixed up with the stools, which appeared at that time to indicate ulceration of the bowel.

CHAPTER XXVII

INTESTINAL ATROPHY

Atrophy of the intestine can be pathologically sub-divided according to its anatomical situation, there being atrophy either of the mucous membrane, follicles, sub-mucosa, or of the muscular coat of the intestines. Clinically, it is extremely difficult to diagnose the site of the anatomical changes in atrophy of the bowel. It would appear, however, that with proper examination of the fæces, one can clinically sub-divide atrophy of the bowel into :

(*a*) Atrophy of the mucous membrane of the bowel, disregarding the question of its affecting the follicles or the general mucous membrane.

(*b*) Muscular atrophy of the bowel.

In illustration of atrophy of the bowel, we select two cases from those which have come under our notice, which may be classified under the above heads.

(*a*) *Atrophy of the Mucous Membrane of the Intestine.*—A male, aged seventy-one, had a distended colon, for which he had been treated three years previously in Germany. During the last year, he had periodically passed blood and mucus six or seven times a day, and unless drugs were employed, the diarrhœa was more or less continuous. He had previously weighed fourteen stone, but when he came under observation he weighed only eleven stone one pound. The patient had a slight aortic murmur, and some arterio sclerosis; otherwise, there was nothing of special note in his condition except the abdominal symptoms. The abdomen was very distended and pendulous, and the colon on percussion and palpation seemed to fill up the whole belly, yielding a splash not only over the cæcum, but throughout its entire length. There was distinct pain on pressure in the umbilical region, but nothing further of moment could be detected. During the time he was under observation, he passed frequent motions, sometimes no less than sixteen or eighteen in the day, when he was taking no drugs. During a period of five days, he was put on a milk diet and analyses carried out. The qualitative analysis of the urine showed only a mere trace of albumen.

TABLE LVII.—DISEASE—ATROPHY OF THE MUCOUS MEMBRANE OF THE BOWEL

DIET: Milk, containing 18·55 grams nitrogen, 109·20 grams fat, 117·60 grams carbohydrates, 2073·06 Calories, 2800 c.c. fluid

Date, June 1901 . .	6	7	8	9	10	Average
Weight in kilos . .	70·65	70·20	69·98	69·75	69·75	70·07
Calories per kilo .	27·90	28·08	28·17	28·26	28·26	28·13
Urine: Quantitative Analysis						
Quantity . . .	2060	2000	2100	1740	1820	1944
Specific gravity . .	1010	1011	1011	1011	1013	1011
Nitrogen . . .	12·77	15·40	15·54	14·62	16·38	14·94
Urea	23·08	26·80	28·98	27·14	30·76	27·35
Uric acid . . .	0·33	0·34	0·17	0·24	0·24	0·26
Ammonia . . .	—	—	—	—	—	—
Phosphates (P_2O_5) .	3·30	4·20	4·20	3·83	3·46	3·80
Chlorides . . .	7·62	4·60	5·46	6·09	3·46	5·45
Sulphates: Total . .	2·14	2·76	—	3·11	2·25	2·57
Sulphates: Alkaline (A) .	1·91	2·44	—	2·88	1·99	2·31
Sulphates: Aromatic (B) .	0·23	0·32	—	0·23	0·26	0·26
Sulphates: Ratio A : B .	8·3 : 1	7·6 : 1	—	12·5 : 1	7·7 : 1	8·9 : 1
Fæces: Quantitative Analysis						
Date, June 1901 .	8	9	10	11	12	Average
No. of motions .	15	13	14	14	14	5 days.
Quantity . . .	133	204	203	255	70	173
Water per cent. .	76·03	76·05	84·88	84·33	85·43	81·60
Nitrogen . . .	1·04	1·60	1·59	2·00	0·55	1·36
Fat	3·73	5·00	3·76	4·99	1·19	3·73
Absorbed nitrogen p.c.	—	—	—	—	—	92·67
,, fat per cent.	—	—	—	—	—	96·58

The quantitative analysis of the urine (Table LVII.) showed a diminution in the quantity of nitrogen relative to the quantity taken in the diet. There was a low uric acid excretion, and, considering that the patient was suffering from diarrhœa, the aromatic sulphates were markedly increased.

The motor-power of the alimentary tract, as tested by means of charcoal, was found to be delayed, for in spite of the frequent motions (there being on the first morning of analysis no less than nine, while six occurred in the afternoon and night, and on the following day, eight in the morning, and five in the afternoon and night), the first charcoal did not appear till 48 hours after its administration by the mouth, and the second charcoal, given on the sixth morning, did not appear until 36 hours after its administration. During the five days of analysis, the motions varied in number from 13 to 15 per diem, and in quantity from 70 to 255 grams. The motions consisted of unformed paste of a porridge-like consistency, and only on a few occasions contained any fæcal lumps. The colour varied from chocolate to reddish brown, and on the third and fourth days some pure blood was observed in the motions. The odour was most offensive throughout, giving the impression of large quantities of indol, phenol, and skatol. At the same time, a distinct smell of sulphuretted hydrogen was noted, this being also chemically recognised.

The chemical analysis of the fæces showed that some of the motions contained practically no increase of mucus, while in others there was some slight increase; in fact, the quantities of mucus alone seemed to negative the diagnosis of mucus colitis. The mucus which was found was of a more or less yellowish colour tinged with blood. The watery extract of all the motions examined gave a distinct albumen reaction. During the period of frequent motions, blood was found to be present on the third and fourth days of fæces analysis, and, in some of the motions, blood corpuscles in large quantities were recognised. No bile pigments were obtained in any of the motions, while the stools, when tested for urobilin, showed a marked excess.

Microscopically, the fæces contained a certain amount of casein and fat globules, together with crystals of ammonium magnesium phosphate and some salts of the fatty acids. On the occasions when blood was found, numerous blood corpuscles were present, as already stated, together with a few leucocytes and epithelial cells. No shreds of mucus could be recognised, so that a diagnosis of ulcerative colitis was negatived.

The quantity of fæces varied very considerably, from 70 to 255 grams being passed in the twenty-four hours, and it is seen on referring to the table that the quantity of water present in the fæces also varied, from 76·03 to 85·43 per cent. When one considers the frequency of the motions, the average of fæces per diem was not very high, being 173 grams, containing 81·60 per cent. of water, the latter also not being so high as one would have expected to find from the apparent markedly diarrhœa. The nitrogen in the fæces varied from 0·55 to 2·00 grams per diem, the average being 1·36 grams, and the quantity of fat varied from 1·19 to 5·00 grams per diem, with an average of 3·73 grams. The absorption of nitrogen was 92·67 per cent., and that of fat 96·58 per cent. It is, therefore, seen that in spite of the frequency of the motions, and in spite of their very fluid appearance, the amount of fluid was not very great, nor the absorption much diminished, the proteid absorption being principally affected. During the period of observation, the patient took 28·13 Calories per kilo, and was kept entirely in bed, there being a loss of weight in the six days from 70·65 to 69·75 kilos.

The patient remained under observation another three weeks, although no further quantitative analyses were carried out. On several occasions, he passed blood in the motions, the quantity steadily increasing. There was considerable flatulency, and towards the end the patient was constantly troubled with hiccough.

The autopsy showed atheroma of the aortic valves with old pleural adhesions. On opening the abdomen, the large intestine bulged out, and the cæcum was larger than a man's head. The large intestine appeared to be greatly distended, and it was so thin that, on trying to remove it, it burst in several places. A small villous growth was found in the sigmoid flexure, and on examination it was seen to be ulcerated at the extremity, which explained the periodical attacks of hæmorrhage. Two erosions were found in the large intestine, and the mucous membrane appeared to be more red than normal.

Dr. Wakelin Barratt was good enough to make a microscopical examination of the large intestine, and reported that the surface was free from epithelial cells, this being probably due to post-mortem changes. The mucous membrane was distinctly thinner than normal, and it would appear that the case may be taken as an example of general atrophy of the mucous membrane of the large intestine. Nothing of note was found in the other organs, which were fairly normal except in the particulars described. The hæmorrhage in this case was a pure accident so far as the atrophy of the bowel was concerned. The general symptoms, such as frequency of motions and pultaceous consistency of the fæces may, however, be attributed to atrophy of the mucous membrane of the large intestine, leading to diminished absorption of water together with diminished absorption of proteids, the fat absorption being little affected, since this is only to a very limited extent carried on in the large intestine.

TABLE LVIII.—DISEASE—MUSCULAR ATROPHY OF THE BOWEL

DIET: Mixed, containing 8·03 grams nitrogen, 33·99 grams fat 39·68 grams carbohydrates, 683·02 Calories, 760 c.c. fluid

Date, January 1902 . .	22	23	24	25	Average.
Weight in kilos . .	65·48	65·03	64·80	64·65	64·99
Calories per kilo . .	10·43	10·50	10·54	10·57	10·51
Urine: Quantitative Analysis					
Quantity . . .	730	840	750	800	780
Specific gravity . .	1023	1022	1024	1024	1023
Nitrogen . . .	10·14	12·56	11·76	12·99	11·86
Urea	18·93	23·52	23·07	25·22	22·69
Uric acid . . .	0·65	0·69	0·64	0·62	0·65
Ammonia . . .	0·51	0·41	0·34	0·64	0·41
Phosphates (P_2O_5) .	1·61	1·85	1·80	1·76	1·76
Chlorides . . .	3·36	4·20	3·81	3·65	3·76
Sulphates { Total . . .	2·10	2·35	2·28	2·35	2·27
Sulphates { Alkaline (A) . .	1·94	2·17	2·13	2·16	2·10
Sulphates { Aromatic (B) . .	0·16	0·18	0·15	0·19	0·17
Sulphates { Ratio A : B . .	12·1 : 1	12·0 : 1	14·2 : 1	11·3 : 1	12·4 : 1
Fæces: Quantitative Analysis					
Date, January 1902 . . .		24	25	26	Average
No. of motions		1	1	1	4 days.
Quantity		34	50	65	37
Water per cent.		74·32	74·32	74·32	74·32
Nitrogen		0·53	0·78	1·02	0·58
Fat		2·64	3·97	5·05	2·92
Absorbed nitrogen per cent.. .		—	—	—	92·78
,, water per cent. . .		—	—	—	91·65

(*b*) *Atrophy of the Muscles of the Intestine.*—We now come to the description of a case which may be classed under the above heading. A male, aged sixty-nine, had suffered from chronic constipation (which had gradually been getting worse), together with marked flatulency, for some twelve or thirteen years. The heart was described as galloping and fluttering, and there was considerable arterio sclerosis, for which the patient had been treated at Nauheim. The flatulency when constipated was so severe that he woke in the night with considerable breathlessness, and some tendency to syncope. On examination of the abdomen, the colon was found to be distended and soft, the rectal examination showing considerable ballooning. There appeared, however, to be little retention of fæces in the rectum, and the constipation was apparently due to the general weakness of the colon itself. A four days' period of analysis was undertaken, during which the diet had to be very limited owing to the patient's dislike for food : and the most one was able to give was 10·51 Calories per kilo. The qualitative analysis of the urine showed nothing of note.

The quantitative analysis of the urine is of interest (Table LVIII.), since we see that, although the patient was taking only 8 grams of nitrogen, no less than 11·86 grams were excreted per diem. In spite of this, very little weight was lost during the period. It is also seen that, considering the small quantity of urea and nitrogen, the uric acid was excessive ; otherwise, the analysis calls for no special mention.

The motor-power of the alimentary tract showed some delay, the first charcoal appearing in 49 hours 45 minutes, and the second in 33½ hours. Motions were passed on only three of the days corresponding to the period of four days when the diet was given. The quantity of fæces varied from 34 to 65 grams per diem, making an average of only 37 grams during the period. The stools consisted of thin rolls mixed with some paste and a little mucus of a brownish colour, the odour being noted as very offensive. The average quantity of water in the fæces was only 74·32 per cent. The chemical analysis of the fæces showed that mucus was present, but no albumen, blood, or bile, the urobilin being only slightly increased. The daily quantity of nitrogen averaged 0·58 grams, and that of fat 2·92 grams per diem. In spite of there being a normal quantity of nitrogen and fat in the fæces, we find that the patient had a very small absorption of proteid, 92·78 per cent., and a still worse absorption of fat, only 91·65 per cent. In this case, it would appear that the constipation was due to atrophy of the large intestine, which was distended throughout, and seemed to have lost its contractive power. Unfortunately, this must remain supposition, since we were unable to have an autopsy to verify the diagnosis, the patient being still alive.

CHAPTER XXVIII

INTESTINAL ULCERATION

In ulceration of the intestines, one has to include duodenal ulcers as well as the various ulcerative conditions which may arise in the intestine, such as tubercular, syphilitic, carcinomatous and uræmic ulcers. The differential diagnosis between the various ulcerative conditions which may occur has to be made by careful analysis of the patient's history and symptoms, as well as by bacteriological methods. So far as chemical analysis of the fæces goes, we may say that it alone will not enable us to differentiate between the various forms of ulceration; all we can expect from it is aid in making a diagnosis of intestinal ulcer, regardless of its etiology. The text-book theory that the diagnosis of duodenal ulcers arising from extensive burns, emboli, or thrombosis is easily distinguished from that of gastric ulceration by noting the lapse of time between the taking of food and the attack of pain, with various other symptoms, is, as a matter of fact, more theoretical than practical. In considering the alterations which may occur in the fæces in cases of duodenal ulcer, one is at once confronted by the fact that in some cases one gets diarrhœa, and in others—and in the more numerous cases, it would appear—constipation is present. So long as there is no hæmorrhage, one may say that it is practically impossible from the examination of the fæces to make a diagnosis of duodenal ulcer, the diminution of fæces observed in some cases being due to the small quantity of food taken owing to the patient's fear of consequent pain. If hæmorrhage occurs, blood will be recognised in the fæces, the appearance of the blood being practically the same as that found in gastric ulcer.

The generally accepted idea that diarrhœa accompanies ulceration of the intestines—more especially of the large intestine—is only partially correct. The diarrhœa is supposed to be due to the intestinal ulcer exposing parts of the bowel to the irritation of the fæces, thus producing increased peristalsis; in addition to which there is an increased quantity of water in the stools, owing to the diminution of the water-absorbing surface from the destruction of parts of the mucous membrane of the bowel by ulceration, so that theoretically one would have an increased quantity of water and increased intestinal peristalsis to produce diarrhœa. But in spite of this, one often finds in practice cases of even extensive ulceration of either the large or small intestine where no diarrhœa is present. We all know that constipation is a not infrequent symptom in extensive typhoid ulceration. It would appear that, in ulceration of the bowel, one may have either constipation or diarrhœa except in cases where the ulceration occurs in the sigmoid flexure or rectum.

The most important sign in the examination of the fæces for intestinal ulceration is undoubtedly the presence of blood. In fact, if no blood is found in the motion, it is impossible to diagnose ulceration of the intestine from the examination of the fæces. We have already said that in duodenal ulcer there is fairly extensive hæmorrhage in the majority of cases, while in ulceration of the large intestine, the amount of blood present at one time is usually very limited. The quantity of blood is often so small that it cannot be recognised by the naked eye, and is only discovered on microscopical or chemical examination. In cases of possible ulceration of the bowel, the discovery of blood in the fæces together with pus and some fibrous tissue, is sufficient to justify one in considering that one has ulceration of the bowel to deal with. When, on the other hand, blood is not found in the fæces, it is not sufficient to negative ulceration of the bowel unless repeated examinations of the fæces have been made.

In addition to blood as an aid in diagnosing ulceration of the intestine, we have also the fact that one often finds a certain amount of pus present. In some cases one finds distinct sloughs even on macroscopic examination of the stools. The presence of pus in the bowel in any large quantity is, however, in favour of a diagnosis of croupous enteritis rather than of simple ulceration. The value of the recognition of pus in attacks of ulceration of the bowel is also very much lessened by the fact that the higher up the alimentary tract the ulcer is situated, the more likely one is to find no pus present, as the greater part of it is digested in its passage along the bowel.

In cases of ulceration, especially in carcinoma, occurring in the lower part of the colon or rectum, it is not uncommon to find equal quantities of pus, blood, and mucus. On the other hand, as pointed out by Nothnagel, one obtains similar motions containing pus, blood, and mucus in cases of dysentery. By earlier observers, it was thought that follicular ulceration could be diagnosed by the presence of mucus resembling frogs' spawn in the stools, but it is now known that this frogs' spawn appearance is due to altered vegetable matter, either starch or small pieces of fruit, and not to mucus, and undoubtedly it is not significant of follicular ulceration of the bowel.

The chemical examination of the fæces, in cases of ulceration of the intestine, is, therefore, only of qualitative value, and careful quantitative analyses are practically useless.

CHAPTER XXIX

INTESTINAL CARCINOMA

In the lesser diseases of the bowel, more especially in catarrhs and functional derangements, a careful examination of the fæces, both chemical and microscopic, is essential in arriving at a definite diagnosis. In carcinoma of the intestine, on the other hand, whether it is the small or the large intestine or the rectum which is involved, the symptoms and physical signs are of much greater importance than the chemical or microscopic examination of the fæces. It is, therefore, only necessary for us to briefly describe what is found chemically and microscopically in such cases, recognising that it is far more important to make a careful analysis of the patient's symptoms and physical signs in the early stages of malignant disease of the bowel.

In cases of carcinoma in the intestine, as in cases of carcinoma elsewhere in the body, the fact of the blood-count showing an increased quantity of leucocytes is undoubtedly of very great importance in helping to make a correct diagnosis, and an increased quantity of uric acid in the urine will also be of use.

The early stages of carcinoma, which are the most important to recognise if one hopes for any success in treatment by surgical interference, produce practically no alterations in the fæces. If there is carcinoma of the bowel, causing some obstruction to its lumen, one gets the symptoms of obstruction as a natural sequence, but until the carcinoma itself has begun to ulcerate, nothing pointing to the malignity of the growth can be detected in the fæces.

The presence of blood and pus in the fæces should always lead to suspicion of ulceration of some malignant growth of the bowel, unless it is found that the patient is suffering from ulcerative colitis or dysentery.

Constipation is a very frequent accompaniment of carcinoma of the bowel. When the obstruction is situated in the rectum or low down in the large intestine, the motions may be of peculiar shape, either ribbon-like or pencil-shaped. One must remember, however, that it is not unusual to find such motions in cases where there is no real obstruction of the bowel; in fact, these narrow motions are as commonly found in cases of simple spasm of the bowel as in cases of obstruction. Boas[1] has shown that in malignant disease of the bowel it is much more common to find a liquid motion containing some of these pencil-like ejecta than to have the latter alone. In some cases, the constipation is relieved by the occurrence of ulceration, and if, in such cases, the constipation has been of long duration, one gets a series of very copious motions, of a very offensive nature. In advanced cases of carcinoma, where there is very considerable ulceration, it is not at all uncommon for the fæces to have a distinctly cadaveric odour, which is very characteristic of carcinoma of the bowel.

Diarrhœa alternating with constipation is one of the most frequent symptoms in carcinoma of the bowel, though there are apparently some cases where diarrhœa is more or less constant without any constipation. We thus see that in intestinal carcinoma either constipation or diarrhœa may be present. In cases where the growth obstructs the lumen of the bowel, the charcoal may take a very long time to appear in the fæces. The colour of the stools is not at all distinctive; the longer the constipation, the greater the tendency towards dark stools. As already mentioned, the odour of the stools is always very offensive, and when ulceration of the growth takes place, there is a tendency for the normal odour of phenol, indol, and skatol to be masked by the cadaveric odour.

The examination of the mucus in the fæces will often show that there is some catarrh of the bowel present. In most cases, the watery extract of the fæces gives an albumen reaction.

The presence of blood in the stools is of great importance in diagnosing malignant disease of the bowel. It may sometimes be recognised in the comparatively early stages, and it seems that blood which appears in the fæces before there is definite evidence of ulceration of the growth is due to oozing from the malignant growth itself. As a rule, the blood is small in quantity, and in cases where it is derived from oozing, it may be very

[1] *Diagnostik. u. Therapie der Darmkrankheiten.*, Leipzig, 1898, vol. i. p. 96.

intermittent. Where this is observed, it must be considered of great importance, as indicating the possibility of early malignant disease. The presence of bile in the motions of patients suffering from carcinoma of the bowel is of little significance except in those cases where the growth is so situated that it obstructs the common bile duct. In most cases of intestinal carcinoma, it will be found that the urobilin tends to be increased.

The microscopic appearances in cases of carcinomatous disease of the bowel are only of importance in the later stages, where one has ulceration of the malignant growth. In some cases, as already stated, blood is found even before ulceration has taken place ; on the other hand, pus is not present until after the ulceration has occurred, so that the presence in small quantities of both blood and pus is of very great importance in making a diagnosis of malignant disease of the bowel. In rare cases, where the growth has ulcerated extensively, one may find particles of the growth in the motions.

Chemical analyses on different diets appear to be of little use in carcinoma of the bowel. In the few cases where we have been able to carry them out, the results have varied very considerably. One interesting case, however, came before our notice. A barrister, aged forty-eight, had weighed 12 stone two years previous to coming under our observation, when he was found to weigh only 9½ stone. A year previously, he had suffered from periodical attacks of vomiting at night, and an exploratory laparotomy was made. The cæcum showed markedly increased peristalsis, and a malignant tumour was found obstructing the hepatic flexure of the colon. The growth was so closely adherent to the omentum, intestines, and surrounding organs, that it was impossible to remove it ; communication was, therefore, made between the ascending and transverse colon, and the patient made a good recovery from the operation. The tumour, however, steadily grew, though the patient gained strength and weight for two months ; after which he began to lose weight, and a hard lump, the size of an orange, was felt in the region of the cæcum. The liver was enlarged to 5½ in. in the nipple line, and the growth in the cæcal region extended up to the liver.

The patient was put on a milk diet, and an analysis carried out during a period of four days. The first charcoal appeared in

24 hours, the second taking 48 hours to appear in the fæces. The qualitative analysis of the urine showed a uric acid ring with cold nitric acid, and the microscope revealed numerous uric acid crystals and urates in the sediment.

TABLE LIX.—DISEASE—INTESTINAL CARCINOMA

DIET: Milk containing 14·84 grams nitrogen, 87·36 grams fat, 94·08 grams carbohydrates, 1578·44 Calories, 2240 c.c. fluid

Date, May 1905	20	21	22	23	Average.
Weight in kilos	60·98	60·53	60·08	60·08	60·42
Calories per kilo	25·90	26·07	26·27	26·27	26·13
Urine: Quantitative Analysis					
Quantity	2070	1850	1620	1600	1785
Specific gravity	1013	1011	1012	1013	1012
Nitrogen	15·11	14·06	14·90	16·00	15·02
Urea	27·53	24·05	27·70	26·40	26·05
Uric acid	0·12	0·17	0·26	0·19	0·18
Ammonia	0·31	0·17	0·26	0·21	0·24
Phosphates (P_2O_5)	2·19	2·15	3·40	2·40	2·54
Chlorides	9·33	6·85	6·64	5·92	7·18
Sulphates: Total	2·48	2·37	2·63	2·80	2·57
Sulphates: Alkaline (A)	2·11	2·17	2·34	2·50	2·28
Sulphates: Aromatic (B)	0·37	0·20	0·29	0·30	0·29
Sulphates: Ratio A : B	5·7 : 1	10·9 : 1	8·1 : 1	8·3 : 1	8·1 : 1
Fæces: Quantitative Analysis					
Date, May 1905	21	22	23	24	Average
No. of motions	1	1	1	1	4 days.
Quantity	90	105	97	75	92
Water per cent.	71·97	76·61	76·61	74·25	74·86
Nitrogen	0·98	0·96	0·88	0·75	0·89
Fat	6·48	6·30	6·00	4·96	5·94
Absorbed nitrogen p.c.	—	—	—	—	94·00
,, fat per cent.	—	—	—	—	93·20

The quantitative analysis of the urine (Table LIX.) showed that the patient was eliminating more nitrogen in the urine than he was receiving in the diet, and during the period of analysis he gradually lost weight, in spite of taking 26·13 Calories per kilo. The uric acid, alhough it was precipitated by cold nitric acid, was shown to be small in amount, the average being 0·18 grams per diem. (In another period on milk, the daily average was 0·39 grams, and on a mixed diet 0·85 grams.) The aromatic sulphates are seen, however, to be increased in quantity.

The examination of the fæces showed the stools to be only partly formed, and on some occasions, a few scybala were mixed up in the unformed paste. On two occasions, the motions contained some blood, and blood-stained mucus was recognised macroscopically. The microscopic examination showed, together with *débris*, some blood corpuscles and numerous leucocytes. The mucus was found to contain both epithelial cells and leucocytes.

The chemical analysis of the fæces showed an increased quantity of mucus, together with albumen, and as already stated, blood was present in two out of the four motions analysed. The urobilin was markedly increased. During the period of observation, the patient passed a motion each day, the quantity varying from 75 to 105 grams, the average being 92 grams per diem. In spite of the motions being of a very soft consistency, we see that the water in the fæces only amounted to 74·86 per cent., the softness of the fæces being evidently due to the increase of mucus and fat. The stools contained an average of 0·89 grams of nitrogen per diem, and no less than 5·94 grams of fat. We thus see that there was only a slight diminution in the absorption of proteid, 94·00 per cent., of which the probable explanation is that the quantity of mucus increased the proteid in the stools. The fat showed a very marked diminution, being only 93·20 per cent.

A three days' analysis on a mixed diet was also carried out, when the same low absorption of fat was observed, being 93·08 per cent., the proteid absorption being not quite so good as on the milk diet, the average on this occasion being only 92·89 per cent.

In another case of early malignant disease of the bowel, in which a growth in the upper part of the rectum (not large enough to encroach on the lumen of the bowel), was later found at the autopsy, an analysis on a mixed diet with the addition of milk was carried out.

In this case there was no distinct increase in the quantity of uric acid present in the urine, but the aromatic sulphates were increased. The first charcoal appeared in 26½ hours and the second 52½ hours after its administration by the mouth. The stools consisted of unformed fæces of a greenish black colour, the chemical examination showing excess of mucus together with albumen, but no blood or bile; urobilin was present in excess. The green colour of the motions was found to be due to chlorophyll.

TABLE LX.—DISEASE—INTESTINAL CARCINOMA

DIET: Mixed + milk, containing 15·48 grams nitrogen, 67·69 grams fat, 123·04 grams carbohydrates, 1535·66 Calories, 1900 c.c. fluid

Date, July 1901	14	15	16	17	Average.
Weight in kilos	58·27	58·50	59·13	58·81	58·68
Calories per kilo	26·37	26·27	25·99	26·13	16·19
Urine: Quantitative Analysis					
Quantity	1200	1650	1820	1650	1580
Specific gravity	1018	1011	1013	1012	1013
Nitrogen	15·12	12·24	14·41	12·87	13·66
Urea	27·60	21·23	26·93	22·26	24·76
Uric acid	0·57	0·58	0·65	0·58	0·59
Ammonia	—	—	—	—	—
Phosphates (P_2O_5)	2·21	1·81	2·36	2·06	2·11
Chlorides	4·92	4·95	6·13	5·26	5·31
Sulphates: Total	2·70	2·57	2·91	2·51	2·67
Sulphates: Alkaline (A)	2·44	2·33	2·63	2·24	2·41
Sulphates: Aromatic (B)	0·26	0·24	0·28	0·27	0·26
Sulphates: Ratio A : B	9·4 : 1	9·6 : 1	9·4 : 1	9·4 : 1	9·4 : 1

Fæces: Quantitative Analysis

Date, July 1901	15	16	17	18	19	Average 4 days.
No. of motions	2	1	4	3	4	
Quantity	96	108	141	81	94	129
Water per cent.	74·76	69·93	74·16	77·83	74·72	74·28
Nitrogen	1·09	1·45	1·63	0·80	1·06	1·51
Fat	3·93	5·26	5·90	2·91	3·85	5·46
Absorbed nitrogen p.c.	—	—	—	—	—	90·25
,, fat per cent.	—	—	—	—	—	91·93

During the time of observation (Table LX.) it is seen that the patient passed from 1 to 4 motions per diem; the stools were very small in amount, varying from 14 to 65 grams, except on one occasion, when there was one motion of 108 grams. The daily total quantity of fæces averaged 129 grams, and in spite of their pultaceous appearance, only 74·28 per cent. of water was found to be present. The nitrogen in the stools averaged 1·51 grams daily, and the fat 5·46 grams. The absorption of proteid in this case was 90·25 per cent., a marked diminution, and the absorption of fat was 91·93 per cent., also a great diminution. At the autopsy, a malignant growth which was not large enough to cause any occlusion of the bowel, was found just below the junction of the sigmoid flexure and the rectum. A very slight amount of force tore the bowel completely through the infiltrated area. The patient had frequently complained of straining with motions, but rectal examination during life had revealed nothing to account for it. During the time of analysis, no blood was found in the motions. The history of this case was difficult to obtain, as unfortunately the patient suffered from considerable mental derangement.

We have given these two analyses of carcinoma of the bowel, though they show nothing very definite except that in each case the absorption of both nitrogen and fat, especially the latter, was diminished. It remains to be seen whether from a larger number of quantitative analyses of the fæces one may be able to draw any definite conclusions.

CHAPTER XXX

SPRUE (PSILOSIS)

THE fæces in sprue are sufficiently distinctive to require a separate description. The chronic form of the disease is occasionally met with in this country, and the acute form seems to differ from the chronic chiefly in degree.

Illustrating the condition found we will now give a description of a case of sprue which came under our notice. A lady, aged forty-seven, who had lived for some years in the tropics, was suffering from an attack of sprue accompanied by sickness, diarrhœa, and tenderness of the abdomen. The ordinary symptoms of sprue—marked anæmia with a waxy appearance, considerable wasting and raw tongue—were present. The motions varied in number from 1 to 8 per diem, the average being two or three motions daily. The patient was extremely emaciated, weighing only 5 stone 9 pounds when she came under observation, and she was put on a pure milk diet. During the period of analysis, the qualitative analysis of the urine showed a marked increase of indican with some increase of urobilin, otherwise nothing abnormal was noted. During a period of three days the motions were collected and analysed.

The quantitative analysis of the urine (Table LXI.) was only carried out on the first two days of the period, owing to an accident. The quantity of nitrogen taken in the food was 12·99 grams, and it is seen in the table that the average quantity excreted in the urine was only 8·93 grams. At the same time, when we take into consideration the relatively large quantity found in the fæces, there was a very fair proportion excreted in the urine. There was also only a slight relative increase in the aromatic sulphates.

On turning to the examination of the fæces, it was found that the first charcoal appeared 24 hours after its adminstration. During the first day only two motions were passed, one comparatively large, and the other small. On the second day, no less than five motions were passed, and on the third, only one. The second charcoal, given on the fourth morning, appeared in 5 hours and 35 minutes.

TABLE LXI.—DISEASE—SPRUE (PSILOSIS)

DIET: Milk, containing 12·99 grams nitrogen, 76·44 grams fat, 82·32 grams carbohydrates, 1381·14 Calories, 1960 c.c. fluid

Date, June 1904	26	27	28	Average.
Weight in kilos	36·93	36·96	36·73	36·87
Calories per kilo	37·40	37·37	37·60	37·46
Urine: Quantitative Analysis				
Quantity	1100	1000	—	1050
Specific gravity	1010	1013	—	1012
Nitrogen	8·37	9·49	—	8·93
Urea	16·80	—	—	16·80
Uric acid	0·07	0·08	—	0·08
Ammonia	0·36	0·47	—	0·44
Phosphates (P_2O_5)	1·20	1·34	—	1·27
Chlorides	4·07	3·70	—	3·89
Sulphates: Total	1·32	1·61	—	1·47
Sulphates: Alkaline	1·21	1·48	—	1·35
Sulphates: Aromatic	0·11	0·13	—	0·12
Sulphates: Ratio A : B	11·0 : 1	11·4 : 1	—	11·3 : 1
Date, June 1904	27	28	29	Average
No. of motions	2	5	1	3 days
Quantity	208	337	120	255
Water per cent.	79·94	80·26	77·08	79·46
Nitrogen	1·28	2·62	0·52	1·47
Fat	31·28	63·83	12·74	35·92
Absorbed nitrogen p.c.	—	—	—	88·68
,, fat per cent.	—	—	—	53·01

The motions, as a rule, consisted principally of paste with some thin badly formed rolls of a very soft consistency. The colour when not stained with charcoal was greyish-green, sometimes tending to be greyish-white. The odour throughout was most offensive.

The chemical analysis showed an increased quantity of mucus and some albumen, but no bile or blood pigments could be recognised in any of the motions. In spite of the fæces being so colourless, there was a distinct urobilin reaction.

It is difficult to make any definite statements as to the chemical condition generally found in sprue, but the description here given may be taken as an example of what one may expect to find on macroscopical examination. The chemical examination has been very much neglected, and from the reports which one finds on the subject, the results of various observers differ considerably. The subject is one well worthy of further attention.

The microscopical examination in this case showed nothing abnormal, except a possible increase of epithelial cells.

The quantitative analysis of the fæces is of interest. The quantity of the separate motions fluctuated, the smallest being only 31 grams, while the largest was 174 grams, the daily quantity varying from 120 grams to 337 grams, yielding an average of 255 grams. In spite of the apparent liquid consistency of the motions, it was found that there was no great increase of water, the average being 79·46 per cent. The quantity of nitrogen daily excreted varied considerably according to the number of motions, the average being 1·47 grams, showing a distinct tendency to increase. The fat is still more remarkable, since the quantity found in the stools varied from 12·74 to 63·83 grams in the twenty-four hours—the average quantity for the three days being no less than 35·92 grams. It is seen, therefore, that there was a distinct tendency to an increased quantity of nitrogen in the fæces, the absorption being only 88·68 per cent., while the fat absorption was still more hindered, being only 53·01 per cent. This marked diminution in absorption partly explains why the patient did not gain weight in spite of taking a diet containing no less than 37·46 Calories per kilo. In the subsequent eight weeks, during which the motions became less frequent, and altogether more normal in appearance, the gain in weight was only 1½ pounds.

CHAPTER XXXI

INTESTINAL CONCRETIONS, GALL-STONES, PANCREATIC CALCULI, ENTEROLITHS, AND INTESTINAL SAND

INTESTINAL CONCRETIONS

Amongst the concretions found in the fæces, one has to include gall-stones as well as pancreatic calculi. In the examination of calculi, the qualitative analysis seems to be the more important, and the quantitative analysis is, up to the present, of pathological interest only. The first step in the analysis of intestinal concretions is to see how far they consist of organic matter, and for this purpose a small portion of the substance is placed on a platinum spatula and burnt. It is stated that pancreatic calculi on heating yield a peculiar aromatic odour.

GALL-STONES

For the examination of a gall-stone, it is first necessary to reduce it to a powder, and then extract all that is soluble by the aid of boiling water. The residue is further extracted with equal volumes of alcohol and ether. If carbonate of lime is present, the residue will give off bubbles of gas on the addition of hydrochloric acid.

A chloroform extract is made of the residue which, on evaporation of the chloroform, can be tested for bile pigments by the addition of cold nitric acid; if bile pigments are present, one obtains a play of colours.

The easiest method of recognising the presence of urobilin is by the examination of the watery extract by the aid of the spectroscope.

Cholesterin can be easily recognised by evaporating the alcoholic ether extract, care being taken that the evaporation is not too rapid; otherwise, the cholesterin is apt to crystallise out in needles, and not in the distinctive crystalline form so easily recognised by the microscope. The crystals of cholesterin thus obtained, if not recognised microscopically, can be chemically tested.

Cholesterin Tests. *Salkowski.*—A chloroform solution of cholesterin treated with an equal volume of sulphuric acid becomes bluish-red, gradually turning to violet red.

Liebermann—Burchard.—A chloroform solution of cholesterin with ten drops of acetic anhydride and sulphuric acid added drop by drop gives a red, then blue, and finally a green colour ; if very little cholesterin is present, the green colour may appear at once.

The analysis of the various inorganic substances is of little importance, but if desired, it can be easily carried out by referring to any qualitative chemical book.

Gall-stones can be roughly divided into three groups :

(1) Pure cholesterin calculi of a more or less white or yellowish colour, with a smooth or waxy surface ; on fracture, they are seen to consist of radiating or concentric layers of crystals.

(2) Cholesterin pigment calculi, often showing facets, coloured brown or greenish, on analysis found to be composed partly of cholesterin, and partly of calcium bilirubin.

(3) Bile pigment calculi, which are, as a rule, smaller than the other calculi, and of a more or less dark colour. They will be found to contain very little cholesterin, and consist principally of bilirubin lime, though, in some cases, one finds biliverdin, bilifucsin, or bilicyanide. Iron and copper seem to be regular constituents of these calculi.

PANCREATIC CALCULI

Pancreatic calculi are, as a rule, very small, about the size of a linseed seed, of a greyish-white colour with a rough surface, in some cases faceted and of a mortar-like consistency. Chemically, they are found to consist principally of carbonate and phosphate of lime, together with a certain amount of organic matter, albumen, fat acids, neutral fat, soaps, and pigments.

ENTEROLITHS

Intestinal calculi are fairly common in herbivora, but rare in man and carnivora. In man, they are generally oval or round and when more than one is present, sometimes faceted. The colour is yellowish or brownish-grey, and on section, they are found to consist of concentric layers mainly composed of ammonium magnesium phosphate or calcium phosphate. On extraction with ether and alcohol, one finds varying amounts of fat and pigment present; in contra-distinction to gall-stones, the pigment is found to be principally urobilin, although sometimes bile pigments themselves may be present. The nucleus is generally found to be some foreign matter, especially fruit stones, fish-bones, and even shreds of vegetable fibre. These concretions are usually formed in the large intestine, more especially in the cæcum or sacculi of the colon, occasionally in the rectum, and rarely, if ever, in the small intestine.

Another variety of intestinal concretion, which is very common in countries where oat-bran is a principal article of diet, resembles the hair-balls of herbivora. These calculi consist of the remains of oat-bran arranged in concentric layers around some foreign body as a nucleus. They are extremely light, and largely composed of organic matter as will be seen on calcining them. They may contain some calcium magnesium phosphate, together with small quantities of soaps and fats. Hammarsten[1] gives as their composition:

Calcium magnesium phosphate . . .	70 per cent.
Oat-bran	15–18 per cent.
Soaps and fat	10 per cent.

DRUG CALCULI

The habitual use of certain drugs is not uncommonly followed by the formation of calculi, which are found in the motions. The most common of these are undoubtedly those found after taking Salol tabloids (Marshall and Treves). Benzoic acid or shellac sometimes cause calculi, and the habitual use of water containing carbonate of lime may produce small calculi.

INTESTINAL SAND

The presence of substances resembling sand in the fæces is not at all uncommon, these particles being, in some cases, the seeds of fruits (such as figs, gooseberries, strawberries), not to

[1] *Lehrbuch d. Physiologie Chemie.*

take into account larger substances (such as orange-pips, &c.), in fact, all kinds of foreign matter ; and in nervous patients who are fond of examining their motions, the discoveries of peculiar diseases are numerous. Such cases, however, are easily recognised as spurious, and it is hardly worth while to call them instances of false intestinal sand.

A *bona-fide* case of false intestinal sand has, however, been brought before the British public by Garrod,[1] a case due especially to the sclerenchymatous particles of pears which became encrusted with earthy salts. These inorganic salts are easily dissolved in acid, and then, under the microscope, they are seen to be composed of " woody cells, the thick transparent walls of which are traversed by channels running from the narrow cell cavities towards the surface."

Black, sand-like material in the motions is described by American observers as occurring in people who have eaten bananas.

True Intestinal Sand.—True intestinal sand is not at all uncommon, if looked for in the motions. It occurs mostly in patients who have mucus colitis, although it has been described in neurotic individuals, unaccompanied by mucus colitis. It generally occurs in women, but we have seen it in both men and women, and one man came under our observation who had no bowel trouble whatever, but suffered from chronic gastric ulcer, and was in the habit of passing intestinal sand when on a milk diet. It appears to be much more common in individuals who are taking a milk diet, and, as far as our experience goes, we have never found true intestinal sand in any case where the patient has not been taking a diet largely composed of milk.

The sand varies in colour from greyish to yellowish brown, and when washed free of *débris*, is gritty, and to the touch resembles sea sand. Chemically, it is found to contain a large quantity of calcium and phosphorus, together with traces of magnesium and iron. It is insoluble in potassium hydrate solution, and soluble in strong nitric acid with the liberation of bubbles of gas. The organic matrix left behind is soluble in alkalies.

Garrod found in one case of his that the sand contained, in

[1] Duckworth and Garrod, " Study of Intestinal Sand."—*Med. Chir. Trans.*, vol. lxxxiv. p. 389, 1901.

addition to urobilin (which is always present), a purple pigment giving a spectrum not resembling any of the now-known pigments. It would appear that true intestinal sand is probably formed in the region of the cæcum, and some observers consider that it is an excretion from the intestinal mucous membrane. On the other hand, it is quite possible that it is simply the inorganic calcium salts in the milk crystallising under certain pathological conditions. Its importance, except as a curiosity, is very small, as although one gets in some cases colicky pains preceding the passage of the sand, it seems not at all unusual for the patient to have no symptoms whatever during the time that the sand is passed.

Chemical analyses, in the cases of some observers,[1] give the following results :

(1) *Duckworth and Garrod :*

Water	12·40
Organic material	26·69
Inorganic material	61·31
Calcium oxide	54·98
Phosphorus pentoxide	42·35
Carbon dioxide	2·20
Residue, containing traces of magnesium and iron	0·47

(2) *Mathieu and Richaud :*

	Case 1	*Case 2*
Organic material	30·800	45·80
Tricalcic phosphate	64·206	46·68
Calcic carbonate	3·418	5·14
Various mineral substances	1·576	2·38

(3) *Thomson and Ferguson :*

Organic matter	28·5
Inorganic matter	71·5
Calcic carbonate	11·7
Tricalcic phosphate	87·3
Insoluble residue (silica)	1.0

(4) *Berlioz :*

Water	11·25
Nitrogenous organic material of fæcal origin	22·24
Fatty substances	Traces
Phosphoric acid	17·56
Lime	26·22
Magnesia	14·05
Silica	8·68

[1] Duckworth and Garrod, *loc. cit.*

(5) *Marquez :*

Organic matter of animal origin	72
Inorganic matter, consisting of calcium phosphate and traces of carbonate	28

(6) *Biaggi :*

Organic material (by difference water, iron)	29·28
Magnesium phosphate	26·82
Calcium carbonate	43·90

Two specimens of sand were examined in our laboratory by Dr. O. T. Williams. The material was practically insoluble in water, and on heating a small quantity with Millon's reagent, a red colour was seen, and a positive result obtained with the Xantho-Proteic and Biuret reactions.

The organic material contained 10 per cent. of substance soluble in ether. This ethereal extract contained :

22·5 per cent. as free fatty acids.
13·4 ,, combined fatty acids.

After extraction with ether, the remaining sand was acidified and again extracted with ether, and yielded 8 per cent. of fatty acids combined with soaps. The chemical analysis yielded :

Combustible material (organic)	55·6 per cent.
Incombustible material	44·4 ,,

The inorganic residue contained :

Calcium present as $Ca_3P_2O_8$	15·5	per cent.
Calcium not present as $Ca_3P_2O_8$	14·34	,,
Iron calculated as Fe_2O_3	2·96	,,
Magnesium calculated as Mg_2O	0·07	,,
Phosphates calculated as P_2O_5	10·5	,,
Carbonates	1·5	,,
Sulphates	0·6	,,
Chlorides	Trace	

A specimen of both samples on combustion burnt with a pinky-white flame.

An investigation was made (and is still continuing), to find the nature of the material from its organic point of view.

In Specimen II. 10 per cent. of the material was soluble in ether. Of this ethereal extract, 22·5 per cent. was present as free fatty acid, and 13·4 per cent. as combined fatty acid. The remaining portion of this first ethereal extract (*i.e.*, unsaponifiable) gave an iodine absorption value (Hube's method) of 117 per cent., which is higher than that of Oleic acid, and lower than that of Linoleic acid—so that it is possible that this portion (unsaponifiable matter) consists of a mixture of these two acids or their salts. (This is being further investigated in a specimen found since going to Press.)

After the above extraction with ether, the remaining sand was acidified and again extracted with ether, which yielded 8 per cent. of the sand, showing the presence of 8 per cent. of soaps insoluble in ether. (These are still under investigation and will probably turn out to be stearic acid, &c.)

APPENDIX

THE quantities of the different constituents of the diets used for diagnostic purposes have been given in the text. In practice it is found necessary to vàry the quantities of the different ingredients to suit individual patients, and for the sake of convenience in calculation, we have found it useful to have tables giving the quantities of nitrogen, fat, carbohydrates, and calories in given quantities of the different articles of diet.

When first carrying out experiments in metabolism, separate analyses of the diets employed in each case were made, but after an experience of a large number of different analyses, we find it now sufficient to take periodical samples, and compare them with the results we obtained in our early experiments. In this way we have accumulated a large number of separate analyses, and find that, dealing constantly with the same tradespeople, the discrepancies in the results found are well within the limits of experimental error. In the case of foods which we rarely use, we have given the results obtained by König. The analytical figures of London milk are those of Professor Kenwood, and are based on the average of several thousand cases, and the figures correspond with what we have found in some seventy analyses during the last ten years. The figures quoted of other articles of diet are those which we have ourselves obtained in a series of analyses, and with the data given in the subjoined table, calculations as to the quantity of nitrogen, fat, and carbohydrates, as well as calories, can be rapidly made. This table is not only of use for the purposes of analysis, but we have found it of great help when alterations in the diet are necessary for the purposes of treatemnt ; by this means, the desired number of calories can be easily introduced, and the food altered as to its richness in proteid, fat, or carbohydrates, the calories in the diet being kept the same, increased or decreased according to exigencies.

TABLE SHOWING THE QUANTITY OF NITROGEN FAT, CARBOHYDRATES, AND CALORIES IN DIFFERENT ARTICLES OF DIET

Diet.	Nitrogen.	Fat.	Carbohydrates.	Calories.	Author.
Plaice (cooked, 1 oz.) . .	0·93	0·14	0	25·13	Harley and Goodbody
Whiting (cooked, 1 oz.) . .	0·78	0·52	0	24·81	
Sole (uncooked, 1 oz.) . .	0·73	0·43	0	22·96	König
Beef fillet (roast, 1 oz.) . .	1·16	0·57	0	38·75	Harley and Goodbody
Beefsteak (raw, 1 oz.) . .	0·70	2·28	0	39·14	
Mutton (roast, 1 oz.) . .	1·22	3·67	0	65·14	
Chicken (roast, 1 oz.) . .	1·14	0·95	0·29	38·24	
Egg (boiled, one) . . .	1·20	6·86	0	93·99	König
Egg (uncooked, one) . .	1·25	5·95	0	86·08	
Cabbage (cooked, 1 oz.) . .	0·16	0·23	0·45	8·08	Harley and Goodbody
Spinach (cooked, 1 oz.) . .	0·27	0·45	2·95	23·20	
Potatoes (uncooked, 1 oz.) .	0·05	0·03	5·35	23·49	König
Cauliflower (cooked, 1 oz.) .	0·22	0·20	2·60	18·16	Corlette
Rice (uncooked, 1 oz.) . .	0·32	0·20	21·73	99·15	König
Oatmeal (uncooked, 1 oz.) .	0·49	1·80	20·77	116·45	
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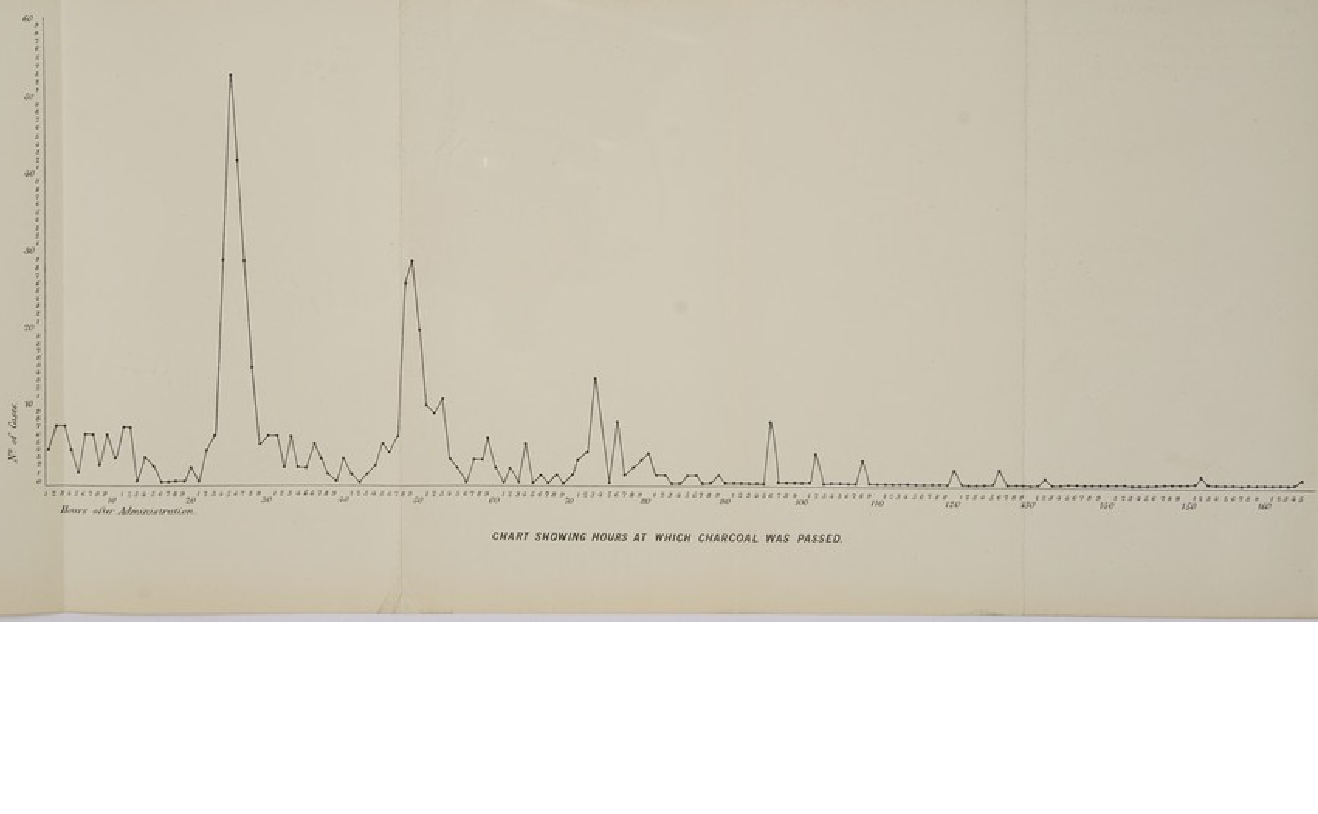

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