In conclusion, I am perfectly well aware that any number of observations, made in the conduct of a single case, cannot be regarded as sufficient data on which to establish the value of tar-water or any other substance as a deodorant in carcinoma uteri; but, in such a case as the one I have given, any means attended with success deserve consideration.

CHEMICAL, PHYSIOLOGICAL, AND PRACTICAL CONSIDERATIONS, IN THE TREATMENT OF PHTHISIS.

By EDWARD SMITH, M.D., LL.B., M.R.C.P., Assistant-Physician to the Hospital for Consumption, Brompton; etc.

[Read before the Western Medical Society.]

A PHYSIOLOGICAL inquiry of great extent, in which I have been for some years engaged, and which in part appears in the *Philosophical Transactions* for this year, has led me to closely examine the chemico-physiological hypotheses of Baron Liebig on the functions of respiration and nutrition, and the basis upon which, in his opinion, all correct practice must be based. The result has been profitable to myself, and has led me to believe that important guides to practice have been found, and may ultimately be multiplied, both in reference to phthisis and to general disease. As the blind administration of remedies is usually profitless, in reference to the advance of science, I venture to hope that the following paper may afford some matter for profitable reflection.

In every case of chronic phthisis, we have to regard the state of the lungs, with the effect of the interference with their functions; the special symptoms, and the state of the general system. In many cases, the intensity of all these so corresponds, that from one we may predict the other; and these are perhaps the purer forms of the disease; but in many there is no correspondence between any of them. Thus a person with all the evidences of a broken system, leading to the inference that it is due to phthisis, has no deposit of tubercle, and may not even have the earlier condition of lessened vesicular action, although that is unlikely; whilst, on the other hand, the system is to all appearance healthy, and, on examination, there is found extensive mischief, and even a cavity in one of the lungs. Again, it often happens that the irritable cough and frequent slight hæmoptysis, so common as symptoms in most cases of phthisis, are accompanied by very slight or even no lung-mischief; whilst, in cases of extensive disease of the lungs, there is scarcely any noticeable complaint of any kind. These various facts are daily exemplified at the hospital, and become so impressed upon the mind, that in no case presenting itself do I dare to form an opinion without first examining the chest; and constantly have I found phthisis where none was suspected, or not found it where I thought it was certainly present. The lesson which I wish to draw from this great want of uniformity in the relation between the disease of the lungs, the symptoms, and the system, is, that phthisis is not one, but, so to speak, many diseases, and requires not one, but many modes of treatment. A belief in this fact must, I think, lie at the foundation of all improvement of treatment.

In reference to the lungs, when tubercle is deposited, we can have no doubt but that some parts of those organs have lost their power of action; and in that earlier condition, in which the vesicular murmur is lessened, the same result is quite evident to my mind. What, then, are the evils which result from this state of things? In a state of health, I can inspire two hundred and eighty cubic inches of air beyond that large amount which remains in the lungs after the most complete expiration; but, in ordinary respiration, I only inspire about thirty cubic inches at an inspiration; and even with the most violent exercise, I cannot inspire more than one hundred cubic inches at each inspiration. Hence it may appear that the lungs are much more capacious than is really required for the due performance of their functions; and this inference seems to be supported by the fact that, in cases of acute pleurisy of one side, with hydrothorax, the other lung remaining sound, all the ordinary processes of nutrition and growth proceed with something like their accustomed order. Such, again, may be inferred from those numerous cases of tuberculosis of the lung in which there are circumscribed deposits even in both lungs, and which exist for years without injury to the individual. But, whilst admitting that Nature has given us a superabundance of lung-surface, in order to be prepared against the inroads of such diseases, we must not hastily come to this

conclusion. The action of the oxygen in respiration probably does not, at least in great part, take place in the air-cells, or indeed in any part of the lungs; but it must be absorbed and conveyed by the blood to the tissues of the body; and in the tissues is doubtless the chief union of carbon and oxygen. Hence are required two circumstances: first, extent of absorbing surface; and second, duration of contact of air with the absorbing membrane. Whatever lessens one or both, must lessen the influence of the respiratory process. There can be no doubt, therefore, that whilst only so small a quantity of air is inspired at an ordinary inspiration as thirty cubic inches, or one-ninth of that which might be inspired, it is distributed to every part of the immense network of the lungs, and in every part the absorption and elimination of gases and vapours proceed. In the early condition of diminished vesicular action—a condition which is more or less general over one or both lung—there will be lessened absorption of oxygen, and lessened elimination of carbonic acid, vapour, and heat. When there is deposition of tubercle, there will also be a more or less complete exclusion of the blood from that part, and thereby an arrest of all the changes just mentioned? What, then, is the result?

It is a common saying, that deficient respiration leads to, or at least is connected with, deficient assimilation and nutrition; but much more precision of ideas is required than is commonly attained. We may perceive, on reflection, that the amount of chemical change proceeding in the body will vary with the amount of vital action, whether in the transformation of nutritive material, or in the destruction of tissue, or, in other words, with the wants of the system; and this chemical change is in great part dependent upon the respiratory function. In this sense, the respiratory function is subservient—that is, it obeys the call of the vital action; but there is another sense in which it must be regarded as exciting and controlling vital action by means of the oxygen which it furnishes, and which, being introduced, excites or increases vital action. In illustration of the former, we may cite the action of the cereals, milk, and sugar, which excite the respiratory function, and particularly that of exertion, which is the most powerful agent known; whilst, in reference to the latter, it may be stated that the respiration increases as the density and coldness of the air increase (apart from the influence of cold upon the body), and with increased voluntary depth or frequency of respiration, the body being at the same time at rest. The curious fact, that a given degree of exertion in two different temperatures or seasons is accompanied by different amounts of respiration, illustrates both, but chiefly the former.

On the latter theory we explain the lessened amount of vital action in phthisis, accompanying the lessened vesicular action and diminished amount of air inspired, quite as rationally as by that which assumes that the latter circumstances are due to the lessened wants of the system. But Liebig has carried this further, and has inferred, because there is wasting in the disease, that there is a hyperoxygenation of the blood, and, indeed, that the prime evil is this superoxygenation. The highly oxygenised products of secretion—as, for example, the acids passing from the system—are regarded by some as proofs of the truthfulness of this opinion. Rokitansky has made use of this in his doctrine of fibrine-crises of the blood in phthisis, stating that the fibrine of the blood is expended in the formation of the tubercle; but he has seen good cause to induce him to give up this doctrine of the crises. This doctrine of hyper- or hypo-oxygenation is of great moment in treatment, since, if there be hyperoxygenation, increase of respiration is contra-indicated; but if there be hypo-oxygenation, as is assumed by Dr. Churchill in his doctrine of the value of the hypophosphites, then we are justified in our directions as to the increase of exertion in the open air. Here, again, we are reminded of diversity in the nature of phthisis; and whilst we must admit that, in the majority of cases, there is hypo-oxygenation, in some, perhaps the more acute, and probably those in which the disease is more advanced than the system indicates, there may be hyper-oxygenation.

The importance of this question, at this stage of the inquiry, is as to the direct effect upon the functions of the blood. One great function is the elimination of carbonic acid. It is evident that, wherever the union of oxygen and carbon occurs, and the most so if it be in the intimate structure of the tissues, the removal of it by the blood must be by a temporary combination of it with a base, or absorption of it by the blood as a fluid, and its subsequent discharge at the right time and place. Both actions must be temporary and repeated, and be due to the aid of other agencies. It cannot be physically accounted for by the

faculty of absorption by a fluid alone, although it has been proved that with soda there is greater capacity to absorb carbonic acid than with any other; and, in reference to the other alternative, Liebig has stated that the base is soda; and that, when the carbonic acid joins the base, it discharges the phosphoric acid. The subsequent discharge of the carbonic acid in the lungs is due chiefly to the diffusion of gases, and its rapidity is believed to vary inversely as the quantity of carbonic acid existing in the air in the air-cells.

Hence it is evident that the process of oxygenation and depuration—and thereby, indeed, of all the vital changes—depends upon the due relation between the acid and the alkali in the blood, and their due interchanges; and, in order to show the paramount importance of this mode of studying phthisis, I need only to quote the remarks of Liebig; viz., “that the law which regulates the dependence of the quality and functions of the blood on the nature and amount of its incombustible elements, is the foundation-stone of medicine and physiology. This only can make medicine a rational science.” This is a view to which I attach the utmost value; but, as it is impossible to discuss it largely on this occasion, I shall only mention two circumstances as bases for treatment. It is essential that there be free alkali in the blood, so that the general quality of that fluid shall be slightly alkaline, since otherwise the iron could not be held in solution, conversion of acids cannot occur, the albumen would tend to coagulation, and the blood would transude through the vessels. When we recollect the quantity of acid which we take directly, and the amount which is formed indirectly from food, and carried into the blood, we readily see how powerful must be the antagonism of these two agents in the blood, and that, at numerous parts of the mass, there will be temporarily (and particularly during digestion) an excess of free acid, rendering such parts unfit for the oxygenating process. Normally this acid, if uncombined, passes off quickly by the secretions; and if combined with a base, it is further oxidised, and is resolved into carbonic acid, and thereby the due balance is restored. But if there be deficient oxygen, or if the acid is produced in excess, or the secretive functions are disturbed, the blood remains deteriorated. In this way we account for excessive acidity of the blood. Again, whilst an alkali is essential to the process of combustion, an acid is equally essential to the formative process; and therefore the muscular fluid, as indeed the fluid in every tissue, has an acid reaction. If, therefore, there be a deficiency in this acid, whether by excessive excretion of the phosphoric acid, or deficient supply of the phosphoric or hydrochloric acids, the formative process is retarded, and waste will follow.

It is therefore true that excessive waste will occur from two different causes; viz., from excess of acid and excess of alkali in the system; and that each, perhaps, is equally injurious. Now, we know that acids and alkalies constitute the great part—indeed, on reflection, we might say almost all—of the remedies in phthisis, as, indeed, in most diseases; and by practice we attain to a sort of undefined notion as to the cases in which they are respectively applicable. The difficulty is to determine with accuracy these respective states. In reference to the acid state of the blood, I think we may always affirm that unusual acidity of the excretions (not due to local states of disease of the excreting organs) indicates an excess of free acid in the blood; and, in phthisis, I am disposed to consider the state of the skin-excretion as the best indication of this state of things. If, in such cases, I find that the perspiration has a sour odour (and the number of such cases is legion), the administration of a combination of the carbonates of soda and potass, say fifteen or twenty grains of each combined, or of the acetate of ammonia, thrice a day, is followed by the happiest results; and the measure of the effect is still the state of the perspiration. This immediately tends to increase the oxygenating process, but it does not of necessity remove that state of assimilation by which an undue amount of acid is thrown into the blood (assuming that, on inquiry, the excess of acid is owing to that circumstance); and hence a reduction in the starchy and saccharine food, and the invigoration of the system by change of air, etc., must be added. The amount of perspiration does not guide us in this matter; for in many cases, with excess of acid, there is profuse sweating; and with profuse sweating we are accustomed to associate acid in our treatment, yet, in such cases, the proper administration of the alkali tends to remove this excess of perspiration. I have recently had a case of early phthisis under my care, in which there was a constant excessive elimination of acid by the skin, and which, without other symptoms than excessive and general exhaustion and wasting, did not progress satisfactorily during three or four

months. Under the influence of the combination of potass and soda, he had a very profuse sweating, accompanied by an exceedingly acid and acrid odour; and obtained immediate and almost marvellous relief. The following is a short account of this case:—

J. E., a young single man, aged 20, engaged in a grocer's shop in the country, had complained for three months of bad appetite, with brown tongue, foul breath, and slight emaciation. There was slight hæmoptysis occasionally, with slight dyspnoea. There was scarcely any cough, but the throat had been sore from the commencement of his disease. The general expression of the symptoms was nervous exhaustion and muscular debility. The chest presented no signs of disease, except the slightest shade of dulness on percussion, and lessened respiration on the left side.

On August 21st, he began to take iron, with a mineral acid and quina. Cod-liver oil was added on August 28th. In September, he continued in the same state, but with a little increase of cough and debility. In October, the cough continued, but he felt a little general improvement. There was also a little pain in the left breast. His state was becoming more anæmic; and the iron, being intermitted for a time, was renewed in November. During all this period he took out-of-door exercise, used salt and water ablutions; and was directed to take milk and other nutritive kinds of food at short intervals.

Thus three months passed away, without any visible improvement; and the progress of the lung-disease appeared imminent. At the end of November, however, he had a most profuse sweating during four nights, in frosty weather, accompanied by an exceedingly sour and acrid odour, which appeared to be the crisis of his condition; for, under the influence of bicarbonate of potass and gentian, he improved most rapidly, and the increase of perspiration, with its acid state, ceased in December. Throughout January he continued to improve, and became again cheerful, active, and strong; and the cod-liver oil being again prescribed at the beginning of February (it having disagreed with him in the early part of his attack), caused so much improvement in a fortnight, that he was led to look upon it as the principal means of his restoration to health. I cannot but think that, if the alkaline treatment had been begun earlier, we should have been spared some anxiety. The case shows well the peculiar condition of blood under discussion, the efficacy of the remedy, and the different action of the oil under the two conditions.

It is in this class of cases that I believe fats to be the most beneficial, if their administration is preceded and accompanied by the administration of these alkalies. There can be no doubt that the administration of starch tends largely to increase the acidity of the blood; and there is reason to believe that the action of fats (the other common hydrocarbonaceous material) tends in the contrary direction—a belief based upon the physiological action of fat upon the respiration, the influence of fat over oxygenation, its beneficial action in cold climates, and its influence under the conditions now being discussed. Hence I think that the state of the perspiration offers an important guide for us in the administration of alkalies and fats. A similar remark may also be made in reference to the action of numerous nitrogenous substances over the respiratory functions; for my experiments have proved that they have this action, and also that it is an indirect one by influencing the rapidity of the oxygenating process, and not a direct one by supplying carbon. As I have recently discussed these subjects elsewhere (*Philosophical Transactions*, 1859; *Philosophical Magazine*, December 1859; *Dublin Medical Quarterly Journal*, Feb. 1860), I shall not enter into them here, except in reference to one which, both from its power and its universal employment, should be better understood; viz., tea. We do not take tea without other food, except it be after the principal meal of the day, when the system is still replete with food; that is to say, we do not take it at the period when the blood is unusually alkaline, but when it abounds in free acids. Its action is rapid, and so powerful that a maximum increase of one-fourth or one-fifth of the whole quantity of carbonic acid exhaled is obtained is less than half an hour; and it has so accumulative an action, that twenty-five grains, taken every quarter of an hour, gave an excess of two hundred grains of carbonic acid within about one hour—a quantity of carbon much greater than it contained. Hence it has a most powerful indirect influence in promoting oxygenation, and is especially fitted for the condition in which there is a disposition to excess of free acid. I am desirous to press this upon your attention; for I believe that, in such cases, tea is our best and most certain medicine. I have also found it of great value in cases of night perspiration, when a large breakfast-

cup is taken cold in the night—of greater value far than any other remedy, except the removal of too much bedding, or warmth, or damp. The detection of the exudation of the blood, in which there is an excess of free alkali, is rather by negative than positive indications; but when there is wasting, languor, defective appetite and assimilation, soft and perspiring skin, and no excess of acid in the urine or perspiration, we have the indications of its existence. This is a condition which prevails in hot weather and climates, and one on which the administration of phosphoric as well as the vegetable acids is of great avail. Fat is commonly less indicated, and such remedies as tea may be injurious by increasing the waste. Cold bathing with salt and water is of great value in both classes of cases, but especially the latter; and the preparations of iron in cases of anæmia are then also much more indicated, since the excess of alkali promotes their solution, and permits a larger amount to be collected and retained in the blood. Milk is a food which I advise to be taken at frequent intervals in the day, and especially in the early morning, and is in a degree applicable to both these states of the blood; since, whilst it has a free alkali and albumen on the one hand, it has fat and phosphates on the other. I believe, however, that skimmed milk, or milk made sour, is much more fitted than new milk for cases in which there is no excess of acid; and it will be found to be better borne by the patients. Milk has a direct action, by supplying plastic and heat-forming materials; and an indirect one by its casein, in promoting assimilation. I also take the opportunity of saying that we have been too much led away from the use of milk and cream in supplying fat to the system, by the habit of administering separated oils; and I think it is easily capable of proof that the combination of the oil in a molecular state with the other components of the milk renders it far more assimilable than any separated fat can be, and especially a fat administered alone; that is, apart from the nitrogenous substances which I have proved to be necessary for its assimilation.

It will, I fear, be thought that I have thus taken too chemical a view of the treatment of phthisis; but I believe that it is only in this way that we can rationally explain the results of our treatment, and be led to devise new plans upon sound principles. There can be no doubt that, whilst we have gained much practical knowledge in the treatment of this disease, it has been shown that almost all plans have their admirers, and are therefore in a degree beneficial. We have thus been groping in the dark; and it is only by dividing the cases into classes, with different pathological or physiological indications, and when we can distinguish those classes, that we may hope to show in what manner so much diversity of treatment has been equally beneficial. This view has also the merit of regarding phthisis as a disease to be treated upon the recognised principles of treatment of any disease with its constitutional indications; and the sooner we cease to regard it as a specific disease, or a disease *sui generis*, the sooner we shall be on the road to improvement in our art. If, in cases of general debility, there be a diminution in the respiratory process, by reason of the lessened amount of air inspired and the lessened interchanges of gases, they only differ from the constitutional conditions of phthisis in degree, and not in kind. In the former, the defect is general over the whole lung-surface; whilst, in the latter, there is added a local cause, which arrests the process altogether at those points. The prognosis differs; but the immediate cause of the defective nutrition is essentially the same, varying only in degree. The general and even the special treatment required in the two conditions in nowise differs, except in degree; for in both alike we must seek to increase the amount of respiration. We practically acknowledge this when we give the direction to do everything which is commonly known to improve the general health; and the diet, exercise, and medicines employed, are common to both conditions. From the point of view in which I have been accustomed to regard phthisis for some years, I have considered that voluntary deep inspirations were well fitted as adjuncts to treatment; and this, both because with greater amount of air inspired even voluntarily there is increase in the chemical changes which follow, and because with a lessened degree of distension and vital action proceeding in the air-cells there must be a progressive tendency to a degradation of their structure, and, as I believe, to the filling up of their cavities by epithelium, or the earliest state of tubercle in these organs. The advantage of this method has for advocates no less authority than Lehmann, who, on physiological grounds, commends it in cases of deficient respiration, in bronchitis; and Piörny, who has recently affirmed, as may be seen by an extract in the *Medical Times* of January 5th, 1859, that by this means he has been able to cause a large amount of

expansion in cases where *deposits* even had heretofore prevented it. Dr. Mühry, a German writer, who has recently treated of climate, seasons, and elevation, over the degrees of expansion of the lungs, has supported the view that expansion of the air-cells is a desideratum of great importance. Hence, in addition to my own affirmation that in numerous cases of early phthisis I have been able to increase the existing diminished vital capacity of the lungs, I think there is evidence to convince the minds of those who regarded my plan with distrust, that there is good reason for its adoption, and that it is not too mechanical to be excluded from physiological and even pathological employment. The increase in the function of the lungs, and the prevention of that tendency to deficient expansion of the air-cells, both alike tend to prevent the further deposition of tubercle; and if, from various reasons, they should fail, the present unsatisfactory result of all kinds of treatment leaves us nothing to regret. I cannot but attach great importance to both of these objects; viz., the increase in the vital actions of the vesicles, and their due expansion and expansibility; and both, in fact, are accomplished in our ordinary directions for violent exercise for the maintenance of health.

I cannot avoid the expression of my conviction that in many cases, owing to the deficiency of vital action, whilst the appetite for food is not materially lessened, the system becomes overburdened with ill-digested material, tending to the accumulation of carbon in the blood, and materially impeding the respiratory process. In such cases, diminution of food, with increase in the action of the liver and bowels, do very much to relieve the oppression of the breathing, and to aid in the work of increasing the expansibility of the air-vesicles. In such cases, alcohols are directly contraindicated; and, indeed, in almost all cases of phthisis (excepting, perhaps, those in which the depressed action of the heart is a marked feature), the advantage of the employment of alcohols is apart from, and in spite of, the alcohol.

I do not propose to enter more at length into the inquiry, and shall conclude my observations with one or two remarks of less general application.

It is difficult, in cases of advanced phthisis, to maintain the proper temperature of the body; since, on the one hand, there being less vital action, there is less production of heat; and, on the other, the skin being commonly very active, there is greater waste of heat. Cold perspirations are very common; and I noticed, in some observations which I made hourly during the day and night, that in a very advanced case, the temperature of the breath was so reduced at about 5 A.M., during sleep, as to give a sensation of coldness to my hand. It is in this sense that profuse perspiration is apt to assume its importance. It is evident that, as the fluid perspiration becomes converted into vapour on its exposure to the air, it absorbs a large amount of heat, which then becomes latent, and which, being abstracted from the skin, reduces the temperature of the body. The larger the amount of the perspiration, and the drier and warmer the air, so much more active will be the process of evaporation, and by so much will be the tendency to lower the temperature of the body to that of the surrounding medium. This is a source of danger even in health, when the heat-forming function is in full activity; and is the most common cause of colds. In phthisis, it cannot be obviated by seeking to increase the production of heat, since we cannot greatly increase the chemical transformations; and hence our endeavour should be to lessen the waste of heat. No doubt this may be effected by clothing in a degree beyond our expectations, as is seen in the advantage in this respect which many of the Asiatic nations derive from the use of cloth in even the hottest weather, since the process of evaporation if too active must be thus retarded. It may also be obviated by any remedy which will lessen the activity of the skin-processes, as, for example, by the rapid application of cold salt water; but the most efficacious plan, probably, is inunction of oil. When the skin is covered with thick ointment, we know that parasites die; and when the spiracles of an insect are covered with a thin layer of oil, they cannot act; and there can be no doubt that the application of oil must lessen the process of evaporation, and in a great degree that of perspiration also. It is possible that the oil may in a very small degree be absorbed, and supply heat-forming materials; but its chief action is that of lessening waste of heat, and therefore the necessity for vital action. This is at least my explanation of the well known value of inunction, and I certainly recommend strongly its employment for this purpose. The disease becomes, so to speak, disease of the skin under these conditions; and that organ is a greater

source of immediate danger than the lungs. Indeed, this condition is very common, apart from phthisis, and produces or attends a state of languor, feebleness, defective appetite, mental depression, and general exhaustion.

It may seem out of place to offer a remark as to the best method of relieving the cough in cases of phthisis; but the great success which has attended the small and repeated doses of morphia encourages me to mention it. I believe no other substance is so certain and uniform in its action, and so deserving of confidence. Regarding the cough as sympathetic, when not directly induced by local mischief in the pharynx, I never administer expectorants, but give simply one-sixteenth of a grain of morphia in water, or in two ounces of acacia mixture, four to six times in the day and night. It is a dose which may be repeated in half an hour without injury. It seldom affects the head or the bowels; and, when repeated, I venture to say, will always allay cough, and give sleep. I use no other remedy for the cough, whether in phthisis or bronchitis, and could adduce some thousands of cases to prove the utility of the plan.

6, Queen Anne Street, W.

Notes of Lettsomian Lectures

ON

CERTAIN POINTS CONNECTED WITH DIABETES.

DELIVERED BEFORE THE MEDICAL SOCIETY OF LONDON.

By FREDERICK WM. PAVY, M.D., F.R.C.P., Lecturer on Physiology at Guy's Hospital.

LECTURE I.

[Delivered November 23rd, 1859.]

IN 1848, M. Claude Bernard stated that he had discovered that the liver had a function very different from that usually attributed to it—that, in short, it had a glucogenic power, or the property of forming sugar. This assertion startled physiologists; and now, after it has obtained almost universal credence, the theory of M. Bernard appears in danger of being completely overturned. But, considering the high scientific position of M. Bernard, and the undoubted exactitude with which his experiments were conducted, it is necessary for all who inquire into the same subject to take care that they are not deceived.

The object of the present lectures is first to give a general account of the physiology of the sugar-formation in the animal body.

Sugar exists in the animal body in the form of glucose or grape-sugar; and, fortunately, the chemical tests for it are not only numerous but trustworthy.

A very common method used for detecting sugar is Moore's or the liquor potassæ test. If a fluid containing glucose be boiled with liquor potassæ, the colour of the fluid is changed to sherry or darkish brown. Although this test is useful in the wards of a hospital, it is almost completely useless physiologically; for colour is not to be depended on in strict physiological experiments.

The fermentation-test is generally looked on as more trustworthy; but Berthollet has pointed out that there are several other substances than grape-sugar which undergo an alcoholic fermentation with yeast. This test is very readily applied. If a solution of grape-sugar be added to a little yeast in a test-tube, and exposed for a short time to moderate heat, carbonic acid will be evolved. Alcohol may also be detected. This test has been suggested for determining the quantity of sugar in solution. According to Christison, every cubic inch of carbonic acid denotes a grain of sugar. It is necessary to be careful that for this purpose the yeast is perfectly pure. The ordinary yeast, as obtained from brewers, always contains saccharine matter; which, however, may be easily removed by washing.

Barreswil's and Trommer's tests consist in the use of a cupro-potassic solution. There is an objection to Trommer's test, that the liquid is thick; while Barreswil's solution is transparent. Barreswil's liquid contains the following ingredients:—

Bitartrate of potass	-	-	-	960 grains.
Carbonate of soda	-	-	-	960 "
Caustic potash	-	-	-	640 "
Sulphate of copper	-	-	-	320 "
Distilled water	-	-	-	1 pint.

This forms a beautifully blue and transparent solution; being essentially a tartrate of copper dissolved in an alkali. It is very delicate, and will detect the presence of an extremely minute proportion of sugar. It may also be used in quantitative analysis with the greatest accuracy. A certain amount of sugar is required to throw down the oxide of copper; so that, the quantity of the solution used being known, the amount of sugar may be readily determined.

A modification of this test, used by the lecturer, is the following:—

Tartrate of potash	-	-	-	10 grains.
Sulphate of copper	-	-	-	5 "
Liquor potassæ	-	-	-	2 drachms.

The tartrate here used is the neutral tartrate. The potash and copper are mixed, and the liquor potassæ is added. The same kind of liquid is produced as in Barreswil's solution. There is an important source of fallacy attending this test: if the solution be kept long, it will of itself form a precipitate on boiling, though not so much as from a saccharine liquid. But the liquid is very easily rendered pure by the addition of a little potash.

It has long been known that in diabetes the urine contains saccharine matter. In the seventeenth century, Willis pointed out that diabetic urine was very sweet; and, a century afterwards Cowley isolated the saccharine matter. Later, Rollo thought that he had ascertained that the sugar in diabetes was formed by the action on the aliments of a depraved gastric juice, and that, so formed, it was taken into the circulation and eliminated by the kidneys. No doubt the blood of diabetic patients contains sugar; but its origin—the origin of the abnormal quantity—is not due to vitiated gastric juice. It was afterwards found by Magendie that sugar was formed normally in the intestinal canal during the digestion of certain materials, and that it was thence taken up and carried to the liver.

It is easily shown that, by the action of certain digestive fluids, starch is changed into sugar. If a solution of starch is agitated with Barreswil's solution, no change occurs; but if starch is mixed with a little human saliva, and exposed to a moderate heat, Barreswil's solution will show the presence of sugar. The pancreatic juice has the same effect, as may be proved by obtaining some of this fluid from the pancreatic duct of a dog. This is probably the especial agent in the animal system for changing starch into sugar. The saliva of man has this effect; but not that of the horse or dog; and besides, the materials remain but a short time in the mouth, and the further action of the saliva would be checked by the gastric acids as soon as the food arrives in the stomach. In the intestines, however, everything is favourable to the transformation: the gastric acid is neutralised; there is a sufficiently high temperature; and the alimentary mass and the pancreatic juice are kept for a length of time in contact. [The effect of pancreatic juice on a solution of starch was shown by an experiment.]

If pancreatic juice is mixed with oil, an emulsion is formed: the fat is minutely divided, and rendered fit to be taken up by the lacteals. If fatty matter or oil is mixed with saliva, the mixture is less perfect: in a little time, the oil floats to the top, while in the other case it remains blended with the pancreatic juice.

Sugar, when formed from the ingesta, is taken up by the portal system of veins, and conveyed to the liver. Bernard, who took up the matter where Magendie left it, says that the sugar is carried to the lungs, and there decomposed. It occurred to Bernard that there might be in the liver some material capable of forming sugar independently of the digestive process. To ascertain this, he fed a dog with strongly saccharine food, and traced sugar in the liver, the lower vena cava, the right side of the heart, and the pulmonary arteries as far as the lungs, but no farther. He then fed a dog with animal food alone. On killing the animal, he found a large quantity of sugar in the inferior vena cava, and in the right side of the heart; hence he inferred that there was somewhere a power of forming a saccharine principle. On examining the blood in the portal and abdominal veins, he found no sugar. He suddenly killed an animal fed without sugar or starch, and