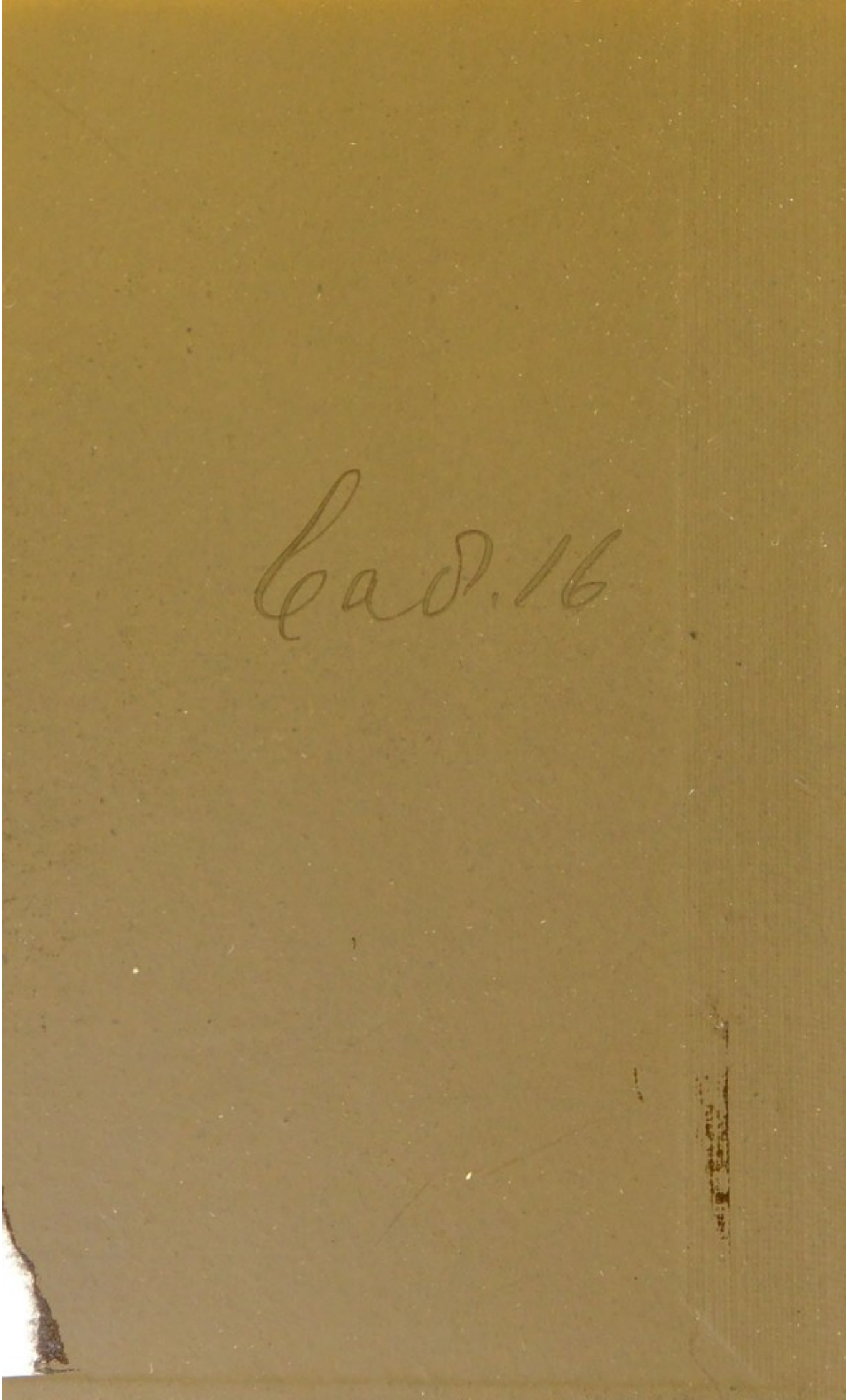
On the relation between diabetes and food and its application to the treatment of the disease / by Arthur Scott Donkin.

ON THE RELATION BETWEEN DIABETES AND FOOD

Dr DONKIN



DIABETES AND FOOD

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BETWEEN

DIABETES AND FOOD

AND ITS

APPLICATION to the TREATMENT of the DISEASE

BY

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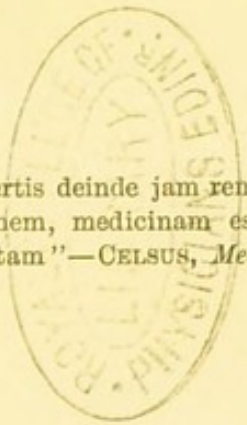

"Repertis deinde jam remediis, homines de rationibus eorum dissere cœpisse; nec post rationem, medicinam esse inventam, sed post inventam medicinam, rationem esse quæsitam"—CELSUS, *Medicinæ* lib. i. præf.

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'To experience we refer, as the only ground of all physical enquiry. But before experience itself can be used with advantage, there is one preliminary step to make, which depends wholly on ourselves: it is the absolute dismissal and clearing of the mind of all prejudice, from whatever source arising, and the determination to stand and fall by the result of a direct appeal to facts in the first instance, and of strict logical deduction from them afterwards.'

SIR JOHN HERSCHEL:
Preliminary Discourse on the Study of Natural Philosophy.

PREFACE.

THIS VOLUME is a clinical essay on a subject which for several years has occupied a considerable amount of attention from the Author. In it he has directed an investigation into the natural history, if he may so express himself, of diabetes, especially with the view of tracing the influence exercised over its progress by the various alimentary principles or compounds which enter into the composition of the ordinary food of mankind living in a civilised state. His object is purely practical: that of advancing the dietetic treatment of the disease—the only resource of medicine against it—into a higher and more perfect degree of development, and of placing it on a rational basis. It is well known

that he has already promulgated opinions on this subject, based on careful experimental observation, totally at variance with doctrines previously taught by many who claim to speak with authority. Consequently, he has been brought into conflict with prejudices of opinion and *chronic* errors, which he trusts he has met in a spirit of philosophical enquiry and shown them to be in opposition to carefully ascertained facts, and no longer tenable.

5 Wimpole Street, Cavendish Square,
London, W.: *July* 1875.

CONTENTS.

DIABETES.

CHAPTER I.

Introductory—Current Theories on the Pathology of Diabetes—the Relation between Diabetes and Food—Views of the Author.

In considering the subject of diabetes, we must carefully avoid confounding with this affection those cases in which diabetic sugar (glucose) makes its appearance in the urine temporarily—from a few hours to a few days or even weeks—and then disappears altogether, its presence in the renal secretion not being accompanied by any of the phenomena of the genuine disease. This saccharine condition of the urine, or temporary *glucosuria*, is merely incidental to other morbid conditions, such as traumatic injuries of the nervous system, engorgement of the vessels of the

liver, and a variety of other causes which it is unnecessary to enumerate. Glucosuria is sometimes caused by the consumption of an excess of starchy or saccharine food, or by their defective assimilation, especially in old age, when it may be intermittent, or even become permanent.

Genuine idiopathic diabetes presents features which are strikingly characteristic, and not observed in any other chronic malady. It is essentially a wasting disease, and, so far as is yet ascertained, not dependent on any structural lesion or organic change of any particular organ of the body.

In carefully studying the clinical history and progress of a *typical* and *uncomplicated* case of diabetes from its initial period to its termination, we observe the development of the following *salient* symptoms, namely: A profuse flow of urine *permanently* impregnated with sugar, emaciation gradually increasing, and at length extreme, not accompanied by any febrile disturbance or increased heat, but, on the contrary, by a marked diminution of the normal temperature of the body. Further, if the disease runs its full course, and life is not cut short by accident, or any secon-

dary morbid condition incidentally developed, death ultimately ensues from inanition or starvation, notwithstanding that the appetite is generally inordinate or even voracious, and the digestion good, so that large or even enormous quantities of the most nutritious food are daily consumed by the sufferer.

In diabetes, moreover, the general emaciation of the body is not produced by any localised structural disease, as in phthisis pulmonalis and kindred chronic affections, in which the softening of a morbid growth, or deposit, produces destructive ulceration of important organs, with attendant wasting, colliquative discharges, and hectic fever. The combination of morbid phenomena presented by the disease is altogether dissimilar and of widely different import.

To the assertion that diabetes is not caused by any recognisable structural disease of any particular organ, it will be objected that the disease is produced by some structural change in the nervous system, located either in its cerebro-spinal or sympathetic division, or in both. It becomes necessary, therefore, at the commencement of the present inquiry, to subject

to a careful examination the evidence on which the various theories of the nervous origin of the malady are based. We are thus, in the first place, brought in contact with the hypothesis of M. Bernard, which of late years has been so widely accepted by the profession.

By a series of well-known experiments, Bernard discovered that *in health* a very important function of the liver in man and in animals, so low down in the scale even as the mollusca, is to form or secrete animal starch (dextrine), to which he gave the name of *glycogen* (since unnecessarily termed *hepatine*, *zooamyline*, *amyloid substance*, &c., by subsequent experimenters). This substance is rapidly changed into diabetic sugar (glucose) by the action of certain ferments, such as saliva, pancreatic fluid, diastase, &c., which effect the same change in vegetable starch or dextrine; but it differs from the latter in being also readily converted into sugar by fresh blood, this latter peculiarity being characteristic.

Glycogen is composed of carbon, hydrogen, and oxygen, in the following proportions: $C_6H_{12}O_6$; it is, moreover, a *colloidal* substance, and not subject to the force of osmosis, so that

it does not dialise through animal membranes. It is secreted by the liver, whether the food be mixed[1] or strictly nitrogenous; but in much greater abundance when the diet is rich in starch and sugar, in the assimilation of which it appears to be the first stage. When formed, it is first of all stored up in the liver cells as a microscopically visible granular substance, and afterwards administers to some important, ulterior purpose in the process of nutrition and in the production of animal heat, being ultimately cast out of the body in the form of carbonic acid and water. But with regard to the intermediate changes through which it passes, much difference of opinion at present prevails; it being contended by many, in opposition to Bernard, that it is first converted into fat.

The experiments of Bernard led him to the conclusion that the *rôle* of glycogen in the animal economy is to be converted into glucose

[1] Dr. G. Salomon, of Berlin, has quite recently shown, by experiments on rabbits, that glycogen is formed by the liver from olive oil, thus contradicting the accuracy of Dr. Pavy's experiments with this substance. (*Virchow's Archiv*, Band lxi. Heft 3.) This is a most important fact in relation to the pathology of diabetes, as will be shown further on.

(grape sugar) in the liver by the agency of a ferment, and then to pass into the venous current of the circulation, to be consumed in the lungs; and, further, that *in a state of health*, the *whole* of the sugar formed by the liver undergoes combustion in the lungs, so that not more than a minute trace passes beyond these organs into the current of the arterial blood.

Bernard further discovered by experiments on rabbits and dogs that puncture of the floor of the fourth ventricle, close to the origin of the pneumogastric nerves, produces a saccharine condition of the urine. This effect he then attributed to paralysis of the vaso-motor nerves, and consequent dilatation of the blood-vessels of the liver, producing excessive functional activity of this organ and a correspondently increased secretion of glycogen, and its conversion into sugar; so large, indeed, that only a portion of the latter can be consumed by the lungs, while the surplus passes into the arterial blood and is excreted in the urine, diabetes being thus produced. To use his own expression in his recent lectures,[1] to be

[1] A translation of these Lectures, delivered at the College of France, is given in the *London Medical Record*, Oct. and Nov. 1873.

presently referred to, 'the nervous system acts on the glycogenesis through the liver, which is the normal secretive organ of glucose; it always acts through the medium of the circulation.'

But in one important respect Bernard has changed his original views, namely, that he now considers the effect produced on the vaso-motor nerves of the liver, by injury of the floor of the fourth ventricle, is *not paralysis but excitation*, which, he says, is the cause of the glucosuria, or artificial diabetes, as he terms it.[1]

[1] 'Two kinds of vaso-motor nerves,' observes Bernard, 'meet each other in the liver and the kidneys; in these organs are nerves which come from the great sympathetic, and others which come from the cerebro-spinal centre. Here the excitor nerve, the analogue of the *chorda tympani*, that which should act on the liver and stimulate its function and circulation, and so increase the production of sugar, must have its starting point precisely in the floor of the fourth ventricle; it must continue its course through the substance of the spinal chord to the level of the first dorsal vertebra, and thence emerge to rejoin the liver. It is by its medium that puncture of the bulb acts upon the gland; its excitation would thus excite the transient artificial diabetes.' I must refer the reader to the lectures just referred to in the text for a full exposition of Bernard's arguments on this subject.

Professor Cyon, by his recent researches, in connection with M. Aladoff, seems to have cleared up the much disputed question as to the channel through which nervous influence passes from the fourth ventricle of the brain to the vessels of the liver in the production of artificial glucosuria. Contrary to the recently expressed opinion of Bernard, he attributes the effect produced on

According, then, to the theory of Bernard diabetes is simply the result of an exaggerated, or greatly increased, activity of an important healthy function of the liver producing an excessive secretion of glycogen, which, in its turn, is converted into sugar, and excreted in the urine. To prevent misrepresentation it is better to quote his own words :—' Glucosuria is then, in fact, only a symptom of a physiological action common to a great number of various conditions. Far from regarding exaggerated glycæmia (saccharine condition of the blood) as a grave prognostic symptom, I would look upon it as the contrary. It

the vessels to paralysis and not excitation. The conclusions at which he has arrived, and which seem to be warranted by his carefully conducted experiments, are the following :—

1. That the artificial glucosuria, produced by puncture of the floor of the fourth ventricle, or section of the last cervical or first dorsal ganglion, is caused by paralysis of the cerebro-spinal branches of the vaso-motor nerves of the liver and dilatation of its blood-vessels.

2. That the course of these cerebro-spinal branches from the fourth ventricle to the liver is from the spinal chord, through the vertebral nerves, to the last cervical and then to the first dorsal ganglion, between which they enclose the subclavian artery, thus forming the *annulus of Vieussens*. From the first dorsal ganglion they pass downwards through the ganglionic chord and splanchnics into the liver. For a full and interesting *résumé* and analysis of the investigations of Cyon, see *Brit. Med. Jour.* Dec. 23, 1871, p. 732.

is vitality reacting; it is essentially a reparative and salutary phenomenon. When glycæmia decreases and disappears, it is because the irritability of the organism is weakened and exhausted; it is then only, if you will, the pathological state commences. In diabetes the glycæmia which precedes the glucosuria is not really a disease. On the contrary, it is an effort of the organism to regenerate itself; a physiological phenomenon analogous to the phenomena of organic development, be it vegetable or animal. The symptoms of a diabetic patient are a trouble, and exaggeration of the nutritive phenomena; the nutrition is not less, on the contrary, it is exaggerated. As I said in a lecture in this course, in a paradoxical form, to become diabetic one must be in good health.'[1] To this opinion, it is to be feared, M. Bernard will not receive the assent of a single physician who possesses any clinical experience of diabetes, for it must be admitted that it is a condition which has, in its most exuberant degree, a remarkable proclivity to a fatal termination.

Dr. Pavy attributes the disease in its more severe form, and when not due to defective assimi-

[1] *Lond. Med. Record*, Nov. 26, 1873, p. 741.

lation of starch and sugar, to a downward metamorphosis of glycogen (amyloid substance) into sugar by morbid action connected with the liver,[1] which he considers to be sometimes distinctly attributable to causes originating in the nervous system.

But it is a well-known clinical fact that the greater the severity of the disease and the more intense it becomes the larger is the quantity of sugar formed and excreted by the kidneys within a given period. It follows, therefore, according to this hypothesis, that the quantity of glycogen secreted by the liver to supply this enormous and ever-augmenting amount of sugar continually voided in the urine must far exceed the normal limit, and ever be on the increase. But as glycogen is a product of healthy, and *not* of diseased secretion, it follows that Dr. Pavy, too, has committed himself to the hypothesis that diabetes depends fundamentally on increased healthy functional activity of the liver. It thus becomes evident that there is in reality no radical difference between Bernard's theory of the disease and that of Dr. Pavy, however far they may

[1] On the Nature and Treatment of Diabetes, 2 Ed. p. 187.

diverge in opinion regarding the destiny of glycogen in a state of health.[1] The chief difference

[1] In opposition to Bernard, Dr. Pavy maintains, as the results of his own experiments, *first*, that in healthy life there is no conversion of glycogen, in the liver, into sugar, and no continual influx of the latter into the current of the circulation, and, consequently, that sugar does not exist in the blood. *Secondly*, that when glycogen is changed into sugar in the liver, and the blood becomes impregnated with it, this is a diseased condition, and constitutes diabetes. And *thirdly*, that the sugar found abundantly in the livers of animals after death is produced by a *post-mortem* change of glycogen.

But recent experimental researches have apparently disproved the accuracy of Dr. Pavy's conclusions. Thus Dr. Lusk (*On the Origin of Diabetes, with some Experiments regarding the Glycogenic Function of the Liver*, New York, 1870), in his experiments on dogs, confirmed, in the first instance, the results obtained by his predecessors in finding no sugar in the liver, if rapidly removed and treated by methods capable of preventing *post-mortem* changes. In the second place, by obtaining blood from the hepatic veins by lifting up the liver and puncturing them as they emerge from the organ. This blood was always strongly saccharine, but the length of time required for the operation afforded room for objection. Thirdly, he made repeated examinations of the blood obtained from the jugular vein and from the right auricle, obtained from the latter by the introduction of a catheter into it, according to the methods and precautions of Bernard. The operation was often repeated, and one ounce of blood withdrawn at each experiment from each source, and with the following results:—

The blood from the jugular vein gave a feeble saccharine reaction with Fehling's test.

The blood from the auricle contained a small quantity of sugar.

It remained to be determined whether *equal* quantities of sugar existed in the jugular vein and right heart. To decide this question, Lusk tested the comparative powers of the extracts of the two bloods in discharging a given quantity of Fehling's solution; the

appears to be that Dr. Pavy dispenses with the agency of the *special* ferment which Bernard con-

result showed that the blood of the right auricle contained a quantity of sugar from two to four times greater than that from the jugular vein, namely, from a quarter of a grain to half a grain to the ounce. The experiment was repeated four times; twice in dogs fasting and twice during full digestion. From these experiments Dr. Lusk concludes: *First*, that Dr. Pavy is correct as to the *post-mortem* nature of the *abundant* sugar production discovered by Bernard in the liver; *secondly*, that sugar is contained in appreciable quantities in the blood of carnivorous animals fed on nitrogenous food; *thirdly*, that the blood of the right heart contains from a quarter to half a grain per ounce, or from two to four times more sugar than that of the jugular vein, and that, therefore, the existence of a quantity of sugar, by no means insignificant, in the hepatic blood, before dilution by the blood of the venæ cavæ, is thus exhibited. Consequently we are forced to admit the formation of sugar in the liver, even although we fail to detect it in the tissues of that organ.

Simultaneously with Dr. Lusk, Professor Dalton (*Sugar Formation in the Liver, by J. C. Dalton, M.D., &c.*, New York, 1871) was engaged in conducting a similar inquiry. Dr. Dalton first of all determined the relative sensibility of the different tests for glucose, the result being that he found Fehling's test to be the most delicate, and capable of detecting so minute a quantity even as the $\frac{1}{1000}$ part of a grain of sugar (glucose) dissolved in one cubic centimètre of water. By means of this test, he proceeded to examine an extract prepared from portions of liver removed from living dogs fed on animal food, using special precautions to prevent the occurrence of *post-mortem* changes in each portion, between the period of its removal from the body and its immersion in alcohol or boiling water; the average time occupied between the former and the latter operation was six and a quarter seconds —the longest time was thirteen, and the shortest three seconds. Dr. Dalton, by the aid of three assistants, made twenty-four experi-

siders to be essential to the conversion of glycogen into sugar. Both are agreed that the *source*

ments, and in every instance the extract obtained from the liver contained sugar; in ten instances a quantitative analysis showed the amount to vary from eight-tenths to four parts per 1,000. To prove that the sugar was not due to the presence of arterial blood, Dr. Dalton excised the spleen in three cases after the removal of portions of the liver. But in none of these instances was sugar detected in the splenic tissues, of which a highly concentrated extract was examined.

From these experiments, conducted with the utmost care and precision, Dr. Dalton believes that the following conclusions may be justly drawn:—*First*, sugar exists in the liver at the earliest period at which it is possible to examine the organ after its separation from the body of the living animal; *secondly*, the average quantity of sugar existing in the liver at this time is, at least, 2½ parts per 1,000; *thirdly*, the liver sugar thus found does not belong to the arterial blood with which the organ is supplied, but is a normal ingredient of the hepatic tissue.

If there is no source of fallacy in the experiments of Lusk and Dalton, it follows that Bernard's theory of the sugar-forming function of the liver must be accepted and restored to its former position. Dr. Pavy's experiments undoubtedly prove that the *abundance* of sugar found in the liver after death is the result of *post-mortem* changes and not a condition of life; but they left the question undecided as to whether or not a *small* portion of this sugar was found during life.

These American researches, moreover, prove almost conclusively that a small but appreciable quantity of sugar is formed in the liver during life, and passes continually into the blood current even in animals fed exclusively on a nitrogenous diet.

The much more recent experiments of Dr. G. Salomon, of Berlin, already referred to, in his elaborate contribution on the formation of glycogen to *Virchow's Archiv* (Band lxi. Heft 3), have led him to the conclusion that the liver contains sugar during life, thus still further confirming the researches of Bernard.

of the latter is the former (the agency of conversion alone being different), except in cases of glucosuria dependent on defective assimilation of starch or sugar, or a superabundance of these in the food.

But in genuine idiopathic diabetes, with all its intense morbid phenomena, it has yet to be demonstrated that the liver performs its function healthfully in the secretion of glycogen, or that this substance really exists in the organ in this disease. On the contrary, the presumption is that it is not so formed, because it is known that glycogen entirely disappears from the liver not only in chronic wasting diseases, but also in prolonged starvation, of which severe advanced diabetes may justly be regarded as a form. Besides, we can scarcely conceive the mechanism of the disease to be: first, the formation by the liver of an abnormally large and ever-increasing quantity of a healthy secretion intended for the nourishment and the warming of the body; and, secondly, its subsequent and immediate conversion into an unoxidisable substance (glucose), which is cast out of the blood as a useless and injurious foreign compound. For, according to the theories of

Bernard and Pavy, such is the sequence of events in the disease.

It is extremely unfortunate that the term diabetes should ever have become associated with artificial glucosuria, produced by experiments on the nervous system of animals, because the latter is always extremely brief and transient, even although the lesions producing it may be permanent. Bernard states that its duration in the rabbit is about five hours, and in the most exceptional cases twenty-four hours; whilst in the dog the extreme limit of its duration is forty-eight hours, and this only seldom. 'The difference of duration,' then, he observes, 'separates the disease diabetes in man from the diabetes that we produce experimentally. All the other characteristics are the same.' A little reflection, however, will show that this latter assertion is untenable; for the fact that the one condition is suddenly induced by injury in a state of health, and is evanescent, whilst the other originates spontaneously as a disease, is persistent, and tends strongly to a fatal issue, leads to the conviction that there is not only a difference of causation, but also a radical dissimilarity of

character. With this conviction Bernard himself seems to have become impressed; so that in singular contradiction to opinions previously expressed he closes the recapitulation of his recent lectures with the following admission:—

'I do not pretend to believe that we have yet arrived at a complete explanation of diabetes; on the contrary, you have seen that we know less about it than we thought we did. Form whatever opinion one pleases of this disease, call it a constitutional dystrophy or otherwise, these are still but empty words, behind which we seek to hide our ignorance of the real cause. Physiology has shown us to-day that we had a false idea of the cause of diabetes; it has shown us that it is not a physiological symptom, glycæmia, or glucosuria, the mechanism of which is perfectly well known to us, that we must attack; it is a more profound cause that we are obliged to seek.' I do not agree with Bernard that the solution of the question is to be found in experimental physiology, but rather in careful clinical inquiry, to which we are indebted for almost all we know of the mechanism of diabetes and the sequence of events observed during its progress.

There is one very important consideration which appears to have altogether escaped the attention of the advocates of the theory that diabetes is the effect of a *neurosis*—producing dilatation (which, of course, must be permanent) of the blood-vessels of the liver by paralysis, either direct or reflex, of their vaso-motor nerves—namely, that hyperæmia or sanguineous congestion thus caused is of so severe a character that it could not persist during the long period over which diabetes usually extends without causing chronic inflammation or some grave structural change in the organ. This seems the more probable when we study the character and effect of congestion, or hyperæmia, so produced when revealed to direct observation. Thus we are all familiar with the effect exercised on the conjunctiva by the impaction of a grain of sand or other irritant, which acts by inhibition or reflex paralysis of the vaso-motor nerves, producing dilatation and injection of the blood-vessels of the membrane, resulting in the most serious consequences if the cause is not removed. That the effect of vaso-motor paralysis on internal organs is equally severe is shown by the experiments of Cyon and Aladoff, who dis-

covered that section of the splanchnics and gangliated chord, causing paralysis of the vaso-motor nerves of the blood-vessels of the intestines, is immediately followed by dilatation and engorgement of these vessels with blood to such an enormous degree that the circulation through the liver is materially affected; and it is asserted that division of the nerves in the mesentery of the dog has been observed to be followed by such intense congestion of the blood-vessels of the intestines that the circulation in the brain becomes insufficient to sustain its activity, so that the animal, while operated on, slept as soundly as if it had been under the action of a narcotic.[1] It can readily be conceived what grave mischief such intense engorgement would produce if persistently maintained either in the intestines or any other important organ. But the liver after death from diabetes is generally free from morbid changes, and certainly presents none of those which would be engendered by prolonged hyperæmia or congestion of its blood-vessels of the character just described.

[1] Dr. Lauder Brunton, *Brit. Med. Jour.*, Jan. 10, 1874, p. 40.

More recently Dr. W. Howship Dickinson[1] has attempted to show that diabetes is caused by certain morbid changes in the substance of the brain and spinal chord. This opinion he has based on certain appearances observed in these organs after death in seven fatal cases in which the disease was more or less advanced.

These structural alterations were similar in all these cases in nature and situation, being located in the white substance of the brain and chord. The earliest change recognised consisted in dilatation of the arteries with accumulation and frequent extravasation of their contents; the next was a degeneration of the nervous matter at certain points outside the swollen vessels. 'The degenerative process occasioned destruction and excavation of the tissues around the vessel. Cavities were thus produced, often large enough to be striking objects even without the microscope, which contained blood-vessels, extravasated blood, grains of pigment, and the products of nervous decay. Finally, the contents appeared to become absorbed, so that simple vacuities were left. The perivascular sheath was variously stretched and

[1] *Medico-Chirurg. Trans.* 1870, p. 233.

altered in character, and became loaded with pigment; but it seemed that these alterations were consequent on the dilatation of the vessel, extravasation of blood, and excavation of nervous matter.'

Dr. Dickinson further states that these changes occurred in constant association with arteries, and were found in every part of the brain and spinal chord, and attained their greatest development in the medulla oblongata and pons Varolii, and were most plentiful where the blood-vessels were largest and most numerous. Enlargement of the central canal was the most conspicuous change observed in the spinal chord. The nerve cells in the brain and chord were generally perfect, and the upper cervical and semi-lunar ganglia of the sympathetic were apparently natural.

As the result of these investigations Dr. Dickinson arrived at the conclusion that diabetes is associated with a substantial change which follows the arteries of the brain and chord, and comprises their dilatation and injection, extravasation, and the destruction of surrounding nerve tissue. He next proceeds to the consideration of the question: *whether the lesion is a*

result of the change of secretion or is antecedent to it. To decide this, he observes, that the association of the morbid change with the blood-vessels suggests that it may be the result of the saccharine condition of the blood. But this interpretation, he contends, cannot be maintained, because the veins and capillaries appeared to take no share in the morbid process, though equally permeated with diabetic blood, which, in the capillaries at least, is brought into more immediate relation with the tissues than in the arteries. For this reason chiefly he decides that the lesion is antecedent to and the cause of the secretion, and, therefore, that diabetes is simply a manifestation or result of cerebro-spinal disease.

In adopting this hypothesis, however, Dr. Dickinson has omitted the consideration of certain very important facts, which seriously affect the premises on which it is founded.

In the first place the structure of the arteries, especially in the brain and chord, and their position in relation to the rhythmic, propelling force of the heart, are altogether different from those of the capillaries and veins. Secondly: saccharine saturation (glycæmia) is not by any means

the only or the most important morbid alteration of the blood in confirmed idiopathic diabetes. Consequently it is essentially necessary to consider the influence which these circumstances most probably exercise conjointly in developing the morbid alterations described by Dr. Dickinson.

When diabetes is fully confirmed, and its primary stage is passed, not only are the whole of the carbonaceous (the saccharine and oleaginous[1]) compounds converted into sugar, but the nitrogenous or albuminous also undergoes the same change to an extent commensurate with the severity of the disease; so that at length a period arrives when, as shown by the accurate experiments of the late Professor Griesinger (to be afterwards referred to), so small a quantity even as only two-fifths of all the albuminous or flesh-forming substances consumed in the food is left available for the nutrition and maintenance of the heat of the body. Consequently the blood is not only saturated with sugar, but it becomes more depraved still, and more unfitted for the

[1] It will be shown further on that in diabetes the oleaginous principles of the food undergo the same complete conversion into diabetic sugar as the starchy or saccharine; although this change of the former begins at a later period than that of the latter.

nutrition of the various tissues, and of the muscular structures in particular, in consequence of its extreme poorness and a deficiency of the pabulum required by each for its nourishment; the result being that general wasting or atrophy sets in, steadily progressing and becoming especially conspicuous in the muscular organs. Not only are the voluntary muscles affected, but the central organ of the vascular system—the heart—also becomes involved; consequently it is difficult to conceive how the walls of the arteries, which are in a great measure tubular muscular organs, can possibly escape from the process, which affects all equally; more especially the arteries of the white substance of the brain and spinal chord, the middle coat of which is purely muscular (the usual investing coat of areolar tissue—the *tunica adventitia*—becomes converted into a thin homogeneous envelope). Should the muscular coat of these arteries become atrophied or thinned, as is reasonable to suppose, they must necessarily lose much of the contractility which normally regulates their calibre and become a prey to the dilating influence of the propelling force of the heart, to which they are constantly

subjected, and thus suffer distension from which the capillaries and veins escape in consequence of being entirely destitute of a muscular coat,[1] and also by their position which screens them from the pulsating action of the heart.

We can thus interpret the structural changes under consideration which, according to Dr. Dickinson, *begin in a dilatation of the arteries*, permitting the accumulation and escape of blood, and followed by degeneration of nervous tissue which becomes absorbed; cavities being thus produced. Because assuming that he is correct in the sequence of events, and that arterial dilatation (not due to previous change outside the vessels) is the initial stage of the diseased process, it must be produced by some morbid cause resident in the walls of the arteries themselves, especially as in diabetes the action of the heart becomes more and more enfeebled.

Dr. Dickinson further contends that we may have recourse to the supposition that the nervous alterations are antecedent to and productive of glucosuria, and abandon the view that they are

[1] According to Kölliker the veins in the substance of the brain and chord contain not a trace of muscular fibre. *Manual of Human Microscopic Anatomy*, London, 1860, p. 242.

due to a diabetic state of the blood, because it traverses the whole of the body without producing any analogous failure of nutrition elsewhere. The reply to this must be that such a failure is observable wherever muscular tissue is distributed, differing only in its manifestation in consequence of the structural peculiarities of different organs.

But considering how very imperfectly the brain and chord are nourished in diabetes, it seems not improbable that some morbid condition in the nervous tissue, rendering it incapable of adequately supporting the walls of the arteries, as in cerebral apoplexy, may contribute more or less in producing the alterations found after death in these organs. But however produced, they are sufficient to account for the numerous cerebro-spinal symptoms which become developed during the progress of the disease; and the fact that these symptoms generally manifest themselves at an advanced period, tends to demonstrate that the alterations in question are simply ravages of the disease. At all events, before Dr. Dickinson's theory can be accepted, it is essential that he should prove beyond all doubt that they exist at the initial period of the malady.

The hypothesis which attributes diabetes to diminished or impeded combustion of sugar, which, according to the theory of Bernard, is always going on in the system in health, can, without discussing the value of the complex and purely physiological data on which it is based, be disposed of by the *palpable* clinical fact that in the disease there is an *excessive* formation of sugar, so abnormally great indeed that in severe instances nearly the whole of the food consumed by the patient is converted into this substance, which is secreted in the urine to the extent even of $2\frac{1}{2}$ or 3 lbs. daily, as already stated; a quantity enormously beyond what can possibly be consumed in the healthy nutrition of the body.

An instructive illustration of this excessive sugar formation is afforded by a case recorded by Dr. Hirschsprung, of Copenhagen:[1] that of a little girl eight years old, and weighing only thirty-seven pounds (2st. 9lbs.), who, while under his observation in the Children's Hospital, voided in the urine in the space of 103 days no less than sixty-three pounds (4st. 7lbs.), or nearly double

[1] Reported in *London Med. Record* for Feb. 25, 1874, from *Ugeskrift for Læger*, vol. xv. No. 25. Third series.

her weight, of sugar; a quantity slightly exceeding nine ounces daily on an average during the whole period; the largest quantity discharged in twenty-four hours was 556 grammes or about 20 ounces. Surely all this could not have been formed for the wants of so small a body, but left unconsumed by the disease, according to the theory of impeded combustion.

The experience of nearly a century—since the time of Rollo—has abundantly established the fact that the intensity and duration of diabetes are powerfully controlled by the composition of the food of the patient; so that it can generally be either arrested or held in check at least by the timely and careful administration of a dietetic method of treatment, while, on the contrary, the symptoms are greatly intensified, and the disease runs a much more rapid course when the diet of the patient is not restricted.[1] We are thus enabled to trace the existence of a direct and special relation between the disease and the food consumed, which supplies it with materials for

[1] No one seems to have been more impressed with this fact than the late Dr. Bence Jones, who observed in his *Lectures on Pathology and Therapeutics* (p. 59. London: 1867) that, 'the effect of diet is far beyond that of any known remedy.'

its activity in the production of diabetic sugar. But this relation, which exercises such an important influence on the progress of the malady, receives no elucidation whatever from the theories which attribute diabetes to an affection of the nervous system, and for this reason they are extremely deficient and unsatisfactory. On the supposition that the affection is a neurosis, how is it possible to explain the singular fact that in its early stage the sugar-forming process appropriates the starchy and saccharine compounds of the food *only*, whilst in its more advanced and severe phase it uses up the albuminous also? Yet the decision of this question is all-important to a correct knowledge of the pathology of the disease.

I have already shown in my numerous contributions on the subject, and my experiments have been confirmed by several competent and impartial observers, that a purely skim-milk regimen completely arrests the formation of sugar, and thus cuts short the disease in a large majority of cases *not too far advanced, or complicated*, and that in a large proportion of these latter even, it enormously diminishes the quantity

of urine sugar, with a correspondent amelioration of the condition of the patient. If this is a clinical fact, as I strenuously maintain it to be, the question naturally suggests itself—What light does it throw on the pathology of diabetes? for we know that the *juvantia* and the *lædentia* of disease frequently supply valuable assistance in the unravelling of obscure pathological problems.

It is impossible to conceive that any particular dietetic treatment could exercise any controlling or curative power over the disease if caused by some affection of the vaso-motor nerves of the liver, or by an atrophy of the brain and spinal chord. It is therefore essential to look in another direction for an explanation.

Without venturing in the present place to enter into a consideration of the therapeutic properties of milk in disease, it is necessary to premise that it is a glandular secretion *designed* specially for the performance of a certain function quite as important and *definite* as that discharged by the gastric juice, or the bile, or any other secretion essential to the maintenance of health: this function being to secure a *perfect* nutrition of the entire body of the young animal subsisting on it

exclusively. Consequently between milk as food and the processes of nutrition and secretion there must exist a *special relation*, as a part of an unerring design everywhere visible in the animal economy. Accordingly, when milk exercises a curative action as a remedy, it may justly be inferred that it acts, in consequence of this special relation, by restoring a healthy nutrition in the part affected, and a healthy secretion in addition, in the case of a glandular organ.

Now the fact that the liver in health secretes glycogen in considerable quantity, together with other facts in relation to this function, point to this organ as the *probable seat* of diabetes, and the source of the sugar so abundantly formed by it.

If, then, diabetes is seated in the liver, and if, in addition, it is so powerfully under the control of a purely skim-milk regimen as is here contended (even after it has passed into the phase in which the albumen of solid animal food is converted into sugar) it is certainly reasonable to conclude that the disease is one of morbid nutrition and morbid secretion of that organ. This is the view, based on a careful study of its clinical history and the effect of treatment on it, which I have been

led to adopt of the pathology of the disease. According to this view the healthy function of the liver in secreting glycogen is suspended, or for the time abolished, and the liver cells secrete diabetic sugar *directly*, as a morbid product, instead; this diabetic sugar being a *new formation*, foreign to the organism, and therefore without a function to discharge: in fact a morbid growth differing from other diseased growths of cellular origin in one essential or specific character, namely, that it is a *crystalloidal* substance which, instead of accumulating or growing, as it is termed, amongst the tissues where it is formed like ordinary *colloidal* formations or products, and leading to the enlargement or destruction of organs, as the case may be, is subject to the laws of *osmosis*, with a strong affinity for water—its endosmotic equivalent. Therefore it passes into the current of the circulation as quickly as it is formed, leaving the tissues in which it is generated intact, uninjured, and unenlarged; hence the difficulty of detecting the seat of its formation.

Confirmatory of the view just expressed of the nature of diabetes, the fact must be noticed that the sugar found in the urine is always the same,

namely, *diabetic sugar* [1]—from whatever alimentary substance it may have been derived: whether from starch, from cane, or grape, or any other form of sugar, or from albumen or any other kind of food.

A very close analogy can readily be drawn between diabetes and certain new formations of constitutional origin and productive of cachexia.

[1] One class of sugars is distinguished by being fermentable with yeast, yielding alcohol and carbonic acid, and also by giving a deposit of oxide of copper by boiling with potash and sulphate of copper. Though having the same chemical formula ($C_6H_{12}O_6$) they differ from each other by their action on polarised light. Diabetic sugar appears to be distinct from glucose formed from starch and glucose obtained from the liver, and indeed from any other kind of glucose, or grape sugar. Cantani has given the name of *paraglucose* to diabetic sugar, which, he maintains, is a non-combustible substance with which oxygen cannot combine. Milk sugar belongs to a different class from these, and is neither fermentable with yeast nor does it reduce copper.

CHAPTER II.

Misappropriation of Food in Diabetes—Diabetic Sugar formed direct from the Food—Glycæmia: the Symptoms produced by it—The relation between the Urine and the fluid Ingesta: the Effect of Osmosis—The Relation between Diabetes and the different classes of Alimentary Compounds—The Malassimilation of Vegetable Starch and Sugar constitutes the first stage of the Disease—Symptoms of the first stage—The conversion of Milk Sugar into Lactic Acid during digestion: Its assimilation in Diabetes proved by the Experiments of the Author.

HAVING in the preceding chapter discussed, what may be considered as hypothetical and uncertain in relation to the seat and nature of the morbid process which constitutes diabetes, it is necessary to proceed to a consideration of what we know with a much greater degree of certainty and precision of the mechanism and phenomena of the disease from its initial period onwards.

The most remarkable, and at the same time the most important pathological character of diabetes is its power of *misappropriating* the food required for the nourishment of the body by con-

verting it in a very *direct* manner into a form of sugar, which being, so far as the wants of the system are concerned, a useless unoxidisable substance, is, after entering the blood, cast out of it in the urine by the kidneys. The result of this is that the blood becomes not only impregnated with sugar, but also more and more impoverished and unfitted for the purposes of nutrition as the disease advances, owing to the withdrawal from it of an adequate supply of the products of the healthy assimilation of the food consumed; thus the tissues of the body are gradually starved for want of the necessary pabulum. These morbid alterations in the condition of the blood are unquestionably the cause of all the characteristic symptoms of the malady, of the wasting and general cachexia, and of the serious complications developed incidentally during its progress, as will be shown further on.

That the sugar is derived from the food is evident, but certain facts show that it is so derived in a very direct manner. Thus the enormous quantity frequently excreted in the urine, daily, for a long period, in severe cases cannot possibly have any other source than the

food consumed by the patient within a few hours previously. Dr. Parkes estimates that the urine sugar often amounts to one, two, and two and a half pounds in the twenty-four hours, but I have met with an instance in which it exceeded the latter quantity. The case of the little girl already referred to, aged eight years, and weighing only thirty-seven pounds, who, while in the Children's Hospital at Copenhagen, passed sixty-three pounds of sugar in 103 days, and lost not more than ten pounds in weight, is a forcible illustration. That fifty-three pounds of this sugar must have been *immediately* formed out of the food of the patient is evident, and it will be shown further on that the remaining ten pounds had the same direct source, the loss of weight having been caused by oxidation and waste of the tissues by inanition.

Further conclusive evidence is derived from the careful experiments of Dr. Ringer,[1] who found in two cases of diabetes—male and female—kept on a strictly nitrogenous diet, that the sugar excreted in the urine began to rise in the third hour after food was taken, and to increase gra-

[1] *Medico-Chirurg. Trans.* 1860.

dually until the fifth hour, when it reached its maximum quantity, and then fell during the next three hours, and almost reached its inanition amount in the eighth hour. Similar results have been obtained by Dr. Parkes.

So soon as the sugar is formed in diabetes, it passes into the blood, producing *glycæmia*, in consequence of its diffusibility and osmotic attraction for water, and possessing at the same time a high density, it increases the specific gravity of the blood serum. It thus brings into action the force of osmosis, so that a considerable influx of water from the fluids of the tissues into the blood through the walls of the vessels by endosmosis takes place. A fulness, or plethora of the vascular system is thus induced, which in its turn excites diuresis and an increased flow of urine. In the next place the loss of fluid which the tissues have sustained creates a want of repletion, and thirst is in consequence engendered. In advanced diabetes nearly the whole of the water drank or contained in the food is excreted as urine by the kidneys. Consequently the quantity of insensible perspiration is enormously diminished, so much so that according to the experi-

ments of Von Dursch [1] only 200 grammes of water pass off by the skin and lungs in twenty-four hours instead of the normal quantity escaping through these channels—namely, 1000 to 2000 grammes. Probably the whole of this small quantity escapes by the lungs. It has also been ascertained that the excretion of water from the intestines is also diminished, but in a less degree.[2]

In this manner, then, certain highly-characteristic symptoms of diabetes are developed, namely, an excessive flow of urine, thirst, a dry, parched mouth, throat, and skin, and constipation. They are all the result of the peculiar physical properties of sugar just mentioned. It follows that the intensity of these symptoms, bearing as they do a mutual relation to each other, must, in every instance, be regulated in intensity by the severity of the disease (modified by the nature of the food taken), and the quantity of sugar produced by it. This is exactly what we find in practice. Thus the quantity of urine voided daily is known to vary from a slight excess to the extent of forty pints, with a corresponding

[1] *Zeitschrift für rat. Med. N.F.*, Band iv. p. 1.

[2] Dr. Parkes, *op. cit.* p. 340.

variation in the dryness of the mouth and thirst experienced.

A circumstance of considerable interest connected with the osmotic properties of sugar requires to be considered here. A belief has prevailed since the time of Celsus,[1] and has been supported by certain eminent authorities of the present day, that the enormous quantities of urine voided by diabetics often exceed the amount of the water consumed in the food and drink, and consequently that there must be in such instances an absorption of water by the skin and lungs, or that it must be formed by the body itself. But the belief in the phenomenon in question appears to have originated in, and to have been perpetuated by a source of fallacy, depending on the fact that water is *retained* for a considerable period in the system in diabetes. So that if our observation to determine the question is limited to a single day, more urine may be passed during that particular day than the water ingested; the cause

[1] At cum urina super potionum modum etiam sine dolore profluens maciem et periculum facit. (*Medicinæ*, lib. iv. cap. xx. sec. 2.) This, by the way, is the earliest description met with of diabetes in ancient medical literature; it is very trite and characteristic of its author.

of this being that a portion of the water consumed on the previous day is voided as urine. But if the investigation is extended over a sufficiently long period—a week or twelve days—so as to exclude this source of error, very different results are obtained. Thus Dr. Parkes refers to the experiments of Nasse, Von Durch, Rosenstein, and others, and records his own, in addition, to show that the quantity of fluid taken exceeds the amount of the urine voided and the water exhaled by the lungs conjointly. 'We may therefore conclude,' he observes, 'that at present there is no reason to think that water is formed in the body. Occasionally, no doubt, the body may for a time lose more water that it receives; it will then lose weight.'[1]

The experiments of Falck,[2] confirmed by Griesinger and Neuschler, have proved that the water drunk by diabetics is not passed so rapidly by the urine as in healthy persons. Thus if a certain quantity of drink is taken in the morning, the urine may not increase until mid-day, but if an

[1] *Op. cit.* p. 340.

[2] *Deutsche Klinik*, 1853, Nos. 22, 23, 25, 26, 31, 39; and Vogel in *Canstatt's Jahresb.* 1853.

equal quantity is taken by a healthy person at the same period, the maximum discharge of urine will be shortly after. In other words, the elimination of water is *retarded* in diabetics, and for this reason, the excretion of urine is *regular*. Falck attempts to explain this fact by attributing it to retarded absorption from the stomach. But the following explanation, given by Professor Vogel,[1] of Halle, is certainly much more satisfactory, being based on the disturbed equilibrium which takes place between the tissue fluids and the blood serum in consequence of the introduction of sugar into the latter. 'When,' he remarks, 'a diabetic is deprived of drink for a certain period, his blood becomes more concentrated in consequence of the urinary secretion which continues. This concentrated blood, richer in solid materials than normal blood, forcibly attracts the water of the parenchymatous fluids (extravascular) until the degree of concentration of the latter is in equilibrium with the serum. But when the healthy individual drinks a considerable quantity of fluid, the water absorbed rapidly augments the quantity of the blood, and consequently the intra-

[1] *Virchow's Handbuch der Pathologie.* Erlangen, 1863.

vascular pressure; diuresis immediately follows, and ceases as soon as the greater part of the water absorbed is thereby removed. But when a diabetic drinks the same quantity of liquid the effect is quite different, even when the gastric absorption is as rapid in the one case as in the other. The blood is diluted by the water absorbed, but the parenchymatous liquids, rich in sugar, are much more concentrated in the diabetic than in the healthy subject; they by exosmotic attraction withdraw from the blood serum a part of the absorbed water, so that immediately after the ingestion of liquid the diuresis is less abundant than in a healthy person. But in proportion as the blood, in consequence of the urinary excretion, attains a higher degree of concentration, it takes back in its turn from the parenchymatous liquids the water it had given them, so that, more slowly, when a considerable interval has passed since the ingestion of drink, the diuresis is relatively more abundant with diabetics than in healthy persons.' Thus, then, there is a continuous alternation, in consequence of disturbed equilibrium, of abnormal or excessive endosmosis and exosmosis at work between the blood-serum and the tissue fluids exter-

nal to the vascular system, maintained of course by the constant influx of sugar into the blood.

This perpetual osmotic action has an important bearing on a very important question which it is necessary to discuss in the present place, namely, whether the solids of the tissues of the body, independently of the food, ever contribute to the production of any portion of the sugar formed by the disease, even in the most severe or advanced instances. The opinion that it is so furnished in advanced cases is based on experimental observations (undoubtedly most accurate, especially those of Traube,[1] Dr. Parkes, and Dr. Ringer,[2]) of diabetics kept fasting for several hours. In the case recorded by Traube, towards the termination most of the sugar was derived from the food, and it was ascertained that after fasting for some hours the sugar gradually diminished as the influence of the food gradually subsided; but it was observed that after the end of a certain time there was no further decrease in the quantity of sugar, and that subsequent to this particular period a uniform

[1] *Virchow's Archiv für path. Anat.* vol. iv. p. 109.

[2] *Trans. Medico-Chirurg. Soc.* 1860.

quantity, namely, 44·7 grains (2·9 grammes) hourly, continued to be voided, although the patient continued without food. Traube considered that this sugar was furnished by the liver.

Dr. Parkes states that, in one of his cases, a large quantity of sugar was furnished in the same manner by the tissues of the body during inanition, and that after seventeen hours' fasting he found the blood still very rich in sugar. He consequently inquires whether this origin of the sugar occurs only in advanced cases, when rapid emaciation is going on, as an abnormal or unnatural production of sugar, or whether it is merely a further stage of the disease which is the consequence of the want of power of destruction.[1]

In the two cases of Dr. Ringer already referred to, in which he made a series of most careful experiments especially for the purpose of determining the quantity of urea and sugar furnished by nitrogenous food, and by the tissues of the body, during fasting and inanition, he found that after the eighth hour and up to the fifteenth hour in one case, and the seventeenth in the other,

[1] *Op. cit.* p. 350.

this being the inanition period, the hourly excretion of sugar in the urine continued, as in Traube's case, almost uniform and undiminished at the end, the quantity excreted hourly in one case having been from 2·4 to 5·3 grammes, and in the second from 1 to 3·7 grammes.

That the sugar excreted in all these cases during the inanition period was derived from the tissues seems most probable, but the supposition that it was formed at the expense of and out of their *solids* is liable to the very grave objection that it can be shown to have been supplied by the tissue fluids by imbibition or endosmosis into the blood, these tissue fluids having been previously impregnated with sugar; or 'rich in sugar,' to use the expression of Professor Vogel.

It is a well-ascertained fact in connection with the pathology of diabetes, that in advanced cases, such as those of Dr. Parkes, Traube, and Dr. Ringer, just referred to, all the tissues and secretions of the body—even the gastric juice, contain sugar in abundance, the result of its osmotic circulation through the body. If then at the end of the eighth hour of fasting, when

the influence of food on the excretion of sugar ceases definitely, and the period of inanition *begins*, there exists, as there most certainly does, a large quantity of sugar dissolved in the fluids of the tissues external to the blood-vessels, and distributed everywhere, this sugar *must* necessarily be excreted during the inanition period in the urine, if diuresis continues, in consequence of the endosmotic absorption of these fluids into the blood as it becomes gradually denser from the continued loss of water, as explained by Professor Vogel. In this manner the blood continues to receive a fresh influx of sugar, which in its turn is excreted by the kidneys, long after the supply from the food has ceased, so that the period of inanition, extending over seven or nine hours in the cases just cited, was by no means sufficiently prolonged to permit of the absorption into the blood, and its subsequent elimination, of the whole of the sugar with which the body was previously saturated.

For these reasons then, it appears to be inadmissible, in order to account for a certain phenomenon, to assume the formation of diabetic sugar

out of the solid materials of the tissues, when its pre-existence in their fluids can be established beyond a reasonable doubt, and therefore such a conclusion cannot be maintained; at least in the first place it will be necessary to show that there is no such source of fallacy as the one just indicated.

Having thus far traced the source of the urine sugar in diabetes directly to the food consumed by the patient, and considered how the presence of this substance in the blood develops some of its most striking phenomena, the next step in the inquiry must necessarily be directed to determining, as far as possible, to what degree, and in what order of succession, the various alimentary compounds or proximate principles are affected or misappropriated by the disease. These compounds being, chemically and physiologically considered, of three classes:—1. The *amylaceous;* comprising starch and the different kinds of sugar. 2. The *oleaginous;* fat, butter, and oils. 3. The *albuminous;* namely, albumen, casein, gluten, &c. The first and second groups being the *carbonaceous*, the third the *nitrogenous*. These substances, mixed in varying proportions, constitute, with the addi-

tion of water, ordinary human food, from whatever source it may be derived, whether from the vegetable or animal kingdom.[1]

This inquiry is one not only of extreme interest in a physiological and pathological point of view, but what is more important still, it supplies the data on which we are enabled to base a correct dietetic treatment of diabetes.

It is a matter of common experience, that in diabetes the ingestion of all alimentary substances containing *vegetable* starch and sugar, produces, in every instance without exception, a great increase in the quantity of sugar excreted in the urine, which also becomes more copious: the increase generally commencing within two hours after such food has been taken, and continuing from four to six hours, or even longer, if the quantity of starch or sugar consumed has been large.

The disease is so very seldom detected at its commencement, that we possess no certain data to show how much starch and sugar contained in the food of a diabetic is mal-assimilated at

[1] The salts required for the nutrition of the body are in combination with the albuminous principles.

this period. But judging from the mildness of the symptoms which then prevail, especially the slight excess of urine and little thirst, it is probable that a small portion only of these substances suffers mal-assimilation, the remainder undergoing the normal metamorphic changes in the process of nutrition and ultimate oxidation in the system.

Numerous experimental observations, as well as clinical experience, show that in the earliest stage of the malady the whole of the sugar found in the urine is derived from the starch and sugar consumed in the food. Thus Mr. Graham[1] ascertained that in two cases of diabetes kept under careful examination for a period of two months, the quantity of urine sugar never exceeded the amount of starch consumed in the food, and that nearly the whole of the starch contained in the latter was accounted for in the sugar excreted in the urine. Traube,[2] too, has recorded an instance in which at one period all the diabetic sugar found in the urine was derived exclusively

[1] Walshe 'On Adventitious Products,' *Cyclop. of Anat. and Physiology.*

[2] *Op. cit.*

from the amylaceous substances in the food. Dr. Parkes [1] likewise refers to a case under his observation in which abstinence from starchy food, or abstinence, completely removed the sugar from the urine and blood, and in which the mal-assimilation of starch was so complete that the smallest quantity taken in the food was excreted in the urine as diabetic sugar. Cases of a similar character have been recorded by the late Dr. Bence Jones,[2] Rosenstein,[3] Mosler,[4] and others; and in fact are so frequently met with in practice that further illustration is altogether unnecessary.

As the disease advances the mal-assimilation, or misappropriation, of vegetable starch and sugar becomes complete, so that the whole of these substances consumed in the food is transformed into diabetic sugar; and as this conversion *continues during the whole period of the disease*, it follows, that no portion, however small, of these compounds is left available for the purposes of nutrition and the production of animal heat. The result is that the supply of one of the mos[t]

[1] *Op. cit.* p. 347.
[2] *Med. Times and Gazette*, Feb. 4, 1854.
[3] *Virchow's Archiv*, Band xii. p. 414.
[4] *Archiv des Vereins*, Band iii. p. 29.

important classes of alimentary substances contained in the ordinary human food of civilised life is completely cut off from the system.

The cases just referred to, and those recorded by Dr. Parkes, Traube, and others, in which, after the lapse of a certain time, diabetic sugar began to be formed out of the albuminous compounds of the food, together with other facts, lead to the conclusion that the period during which there is mal-assimilation of amylaceous substances *only* constitutes the first stage of the disease.

The conversion of the amylaceous compounds of food into diabetic sugar not only deprives the body of the use of these for its healthy nutrition, and poisons the blood with an unoxidisable noxious substance, but in addition, it appears that their mal-assimilation both originates, or determines and intensifies, the saccharine metamorphosis of the oleaginous and the albuminous. In short, starch and sugar appear to be the fuel by which the disease is fed, until it acquires a degree of intensity enabling it to attack and misappropriate these latter substances.

A case recorded by Dr. Pavy[1] (though not for

[1] *Op. cit.* p. 241.

the special purpose to which it is here applied) well illustrates this injurious influence of starch. In this case, at a time when sugar had been entirely absent from the urine under a restricted animal diet, two ounces of ordinary bread were given daily for a couple of days, and then the restricted diet resumed. The result of the experiment was, that the four ounces of bread caused the excretion of 1425 grains of sugar, which was a larger quantity than could possibly have been yielded by the bread itself, as the two ounces of it, after complete desiccation, left a residue of only 600 grains of solid matter, equivalent to 1200 grains in the whole four ounces, only a portion of which was starch. Besides, it was further observed in this case, that the sugar continued to increase for two days, and did not entirely disappear for four days after the bread had been discontinued.

In addition, it is a matter of common experience that when by proper dietetic treatment diabetes has been arrested, or subdued in intensity, the injudicious use of starchy, or saccharine food will generally cause it to break out afresh, and even with redoubled severity. No one was

more impressed with the importance of this fact than the late Dr. Prout, whose recorded experience of the disease extended over 700 cases, and whose practical sagacity was undoubted. In reference to the pernicious influence of vegetable sugar, he observes that 'every variety of the saccharine principle, in its *crystallisable* form, is absolutely inadmissible as an article of food in diabetes. This rule therefore excludes at once all fruits, whether subacid or sweet, as well as every compound, natural or artificial, into which sugar enters. The practical importance of this rule is so great, that I am doubtful, if it be neglected, whether good can be obtained from any plan of treatment. Even its occasional infringement cannot be indulged in with impunity. Thus I have known the use of a few saccharine pears undo in a few hours all that I had been labouring for months to accomplish, and the disease with all its horrors has been re-established in an aggravated form.'[1] The experience of the author is fully in accordance with that of Dr. Prout, inasmuch as he has in some very melancholy instances seen the disease reinduced with redoubled violence by

[1] *Stomach and Renal Diseases*, 5th ed. p. 39.

wilful and clandestine infraction of dietetic rules. Further evidence of the impetus given by starch and sugar to the development of the disease is afforded by the well-known clinical fact, that its progress is most rapid and its symptoms most severe in those cases in which the diet of the patient is unrestricted.[1]

The first stage of diabetes, that in which the amylaceous principles of the food *only* are misappropriated, is certainly the most protracted, and, as pointed out by Dr. Prout, may extend over several years, especially in subjects beyond the middle period of life. Dr. Parkes[2] has expressed the opinion that apparently, in the case of Dr. Camplin, who by appropriate dietetic treatment kept the disease at bay for more than ten years in his own person, it did not advance beyond the first stage. At this stage, in advanced life, it is most protracted, even when we eliminate from the category of diabetes those cases which are simply

[1] I am at a loss to ascertain on what authority Dr. Thudichum states 'that noted physicians now maintain that diabetic patients eating promiscuously everything, are better off than patients who abstain from starch' (*Manual of Chemical Physiology*. London: 1871, p. 9.)

[2] *Op. cit.* p. 347.

instances of glucosuria, often intermittent,[1] from defective assimilation of starch and sugar.

Diabetes at its initial period begins insidiously, and may continue to progress so mildly and imperceptibly during its first stage, as to remain undetected for months or even years; until, in fact, it has passed into its more advanced and formidable phase when the albuminous compounds of the food have begun to undergo saccharine metamorphosis, and when the symptoms of the disease are no longer mistakable, and the condition of the patient may have become irremediable. But in its early stage the malady is certainly amenable to treatment and capable of being arrested in a large proportion of cases, and in the remainder held in check. It is therefore all-important that its symptoms at this period should be understood and recognised without difficulty. In describing these symptoms I will merely repeat what he has already written in directing attention to them,[2] inasmuch as subse-

[1] The cases of intermittent diabetes in old persons described by the late Dr. Bence Jones, seem to have been instances of glucosuria, not of idiopathic diabetes.

[2] *Lancet*, 18 Jan., 1873.

quent experience has confirmed the opinion I have already expressed.

'During the last few years that I have directed my attention more especially to this subject, several cases have come under my observation in which the disease was so far advanced, and had inflicted such irreparable injury on the constitution generally and nutritive process—on the vitality of the organism, if I may so speak—that but little good could be effected beyond subduing the more distressing symptoms. In some of these instances, most unfortunately, the disease had not been recognised until it had advanced in its destructive progress for years; and this reflection urges me to remark that diabetes will still continue too frequently to escape detection in a similar manner, until its symptomatology is re-written in most of our text-books on medicine, thus enabling the student to become familiar with its features in its initial or earliest phase. As hitherto described, the symptoms enumerated are those characteristic of an advanced stage of the malady; namely, excessive thirst, a parched skin, a very large flow of urine, a voracious appetite, and emaciation. Now I

venture to repeat what I have already stated on this important subject, that the invasion and early stage of the disease do not produce this assemblage of symptoms, and must therefore be recognised by a widely different class of phenomena. These are: a general feeling of debility not due to emaciation or loss of flesh, considerable nervous and muscular prostration, lassitude and disinclination for bodily and mental exertion, occasionally a dull pain over the loins, loss of sleep, frequently dimness of vision, a feeling of numbness or loss of sensation over the surfaces of the thighs, a clammy condition of the mouth without much thirst, or preternatural dryness of the skin, which is frequently perspiring. Whenever we meet with this category of symptoms, more or less complete, our suspicions should be aroused and the urine carefully examined for sugar.'

In short the early symptoms of diabetes are a general *malaise* without any obvious cause—especially as the appetite and digestion are usually good—until the urine is subjected to examination. Until the first stage is considerably advanced there is not generally much loss of flesh, unless it is complicated, or occurs in spare subjects of a

tubercular diathesis. The urine is not greatly increased, and the symptoms dependent on the abstraction of water from the system are not urgent, except in some instances after excessive indulgence in saccharine food and drinks. The symptoms at this period are due to the presence of sugar in the blood, and the deficiency or complete absence of the materials normally supplied to the blood by the assimilation of the starch and sugar of the food.

The relation existing between vegetable starch and sugar as alimentary substances having been ascertained, it becomes necessary to determine how far the disease is affected by *lactose* or milk sugar (animal sugar), taken as food in its natural condition *as a constituent of milk*. The determination of this question has a most important practical bearing on the treatment of the disease, and is one concerning which the most vague and unsatisfactory notions have hitherto prevailed in consequence of meagre and unsatisfactory experimental observation.

Rollo,[1] who, acting on the suggestions of Dr.

[1] *Cases of the Diabetes Mellitus.* Lond. 1797.

Francis Home,[1] was the first to originate a systematic dietetic treatment of diabetes, recommended milk to be taken in the regimen he prescribed, and, as an examination of his cases will show, without any injurious effect on his patients. Much more recently his example has been followed by Sir Robert Christison, Dr. Prout, and the late Dr. Bence Jones,[2] who, as the result of his own experience, came to the conclusion that milk sugar is not easily converted into diabetic sugar in the human body.

In 1852, in a memoir to the French Academy of Medicine, M. Bouchardat, of Paris, condemned the use of milk in diabetes as highly injurious, but recommended sweet cream, butter, and all kinds of cheese, and, most unfortunately, his advice has been adopted and repeated by most writers on the subject both abroad and in this country; by the late Professor Niemeyer, of Tubingen, in his 'Elements of Pathology and Therapeutics,' now a

[1] *Chemical Experiments*, 2nd ed.

[2] *Med. Times and Gazette*, Feb. 4, 1854. Subsequently, and as it would appear from insufficient observation, this distinguished physician stated that 'milk sugar is more or less injurious according to the stage of the complaint; when animal sugar can be consumed, milk sugar is comparatively harmless. *Lectures on Pathology and Therapeutics.* Lond. 1867, p. 62.

text-book in this country; by Dr. Pavy, and by Dr. Jaccoud, of Paris, who, in reference to the restricted animal regimen of his countryman, observes:[1] 'Mais c'est notre savant hygieniste, le Professeur Bouchardat, que a donné les règles complètes et méthodiques de cette médication.'

But notwithstanding the wide acceptance which the views and method of treatment of Bouchardat have received, I have no hesitation in stating as my mature conviction, derived from sufficient experience, that they have operated most perniciously, and, more than any other cause, have prevented the development of a proper and effective dietetic treatment of diabetes.

Dr. Pavy has adopted the recommendations of Bouchardat so far that he has published in a tabular form[2] an elaborate dietary for the use of diabetics; and in this table, at the very head of the list of proscribed saccharine liquids, milk is placed as being equally or more injurious than beer, stout, sweet wine, and other drinks rich in vegetable sugar, and therefore inadmissible as

[1] *Nouv. Dictionnaire de Méd. et de Chirurg. pratiq.* tome xi. p. 316. Paris, 1869.

[2] *Op. cit.* p. 263. This table has been reproduced in his recent work on dietetics, without any modification in regard to milk.

food or drink to those suffering from the disease. Dr. Pavy conducted a series of experiments—the results of which he has given in a tabular form in his work—on a patient named North, extending over a period of nearly two months, with the view of determining the effect produced on the quantity of sugar excreted in the urine by different kinds of food. In this case, three pints of milk were taken for two days in addition to a strictly meat diet, and on the next two days half a pound of suet was added daily to this diet. The result obtained was that at the end of the first two days the sugar in the urine had greatly increased, while at the end of the fourth day its quantity had nearly doubled. In the next chapter the details of this experiment will be more fully entered into, and it will be shown that this increased formation of sugar by the disease was caused by the influence of fat—butter and suet—consumed by the patient.

But Dr. Pavy arrived at a widely different conclusion, and attributed the evil effect produced to the action of milk sugar. 'It would be an unintelligible exception,' he observes, 'if the presence of lactin did not render milk an objectionable article of food in diabetes.' In expressing this

opinion, based in a great measure on hypothetical grounds, Dr. Pavy was evidently not acquainted with the fact pointed out long previously by the late Dr. Bence Jones,[1] that during digestion milk sugar, *as a constituent of milk*, is converted into lactic acid through the action of casein as a ferment; and that he further advanced the opinion that one, at least, of the most important physiological uses of milk sugar is to be so changed into lactic acid in the stomach for the purpose of dissolving the albuminous capsules of the milk globules. In short, during the digestion of milk, the sugar it contains undergoes the same change as when milk becomes sour or acid, and coagulated into curd, by long keeping or certain states of the atmosphere.

Those who, with Dr. Pavy, believe that lactose must be injurious in diabetes because it is a species of sugar, do not take into consideration the very important fact that it has widely different chemical properties and physiological relations from diabetic sugar and the other forms of glucose. Belonging to a different class of sugars,

[1] 'Lectures on Digestion, Respiration, and Secretions,' *Med. Times and Gazette*, April 19, 1851.

it does not undergo *alcoholic* fermentation in contact with yeast, and, in addition, it does not precipitate the oxide of copper when treated with the reduction test. On the other hand, it is subject to *lactic* fermentation by the action of ferments. On account of these intrinsic differences, lactose, as an ingredient of milk, cannot undergo the same metamorphic changes as glucose in the processes of digestion and assimilation in health (nor be converted into it in diabetes); its conversion into lactic acid being *direct* and *immediate*, not by *intermediate* changes through which the latter pass into this substance.[1] For this reason, which is perfectly intelligible, milk sugar, unlike vegetable glucose, is assimilated, and the reverse of injurious, in diabetes.

[1] That lactic acid does not in the slightest degree contribute to the formation of diabetic sugar has been shown by the experiments of Professor Cantani, who has recently introduced it into practice as a remedy for diabetes, and by those who have repeated his experiments in this country; especially Drs. Balfour of Edinburgh and Balthazar Foster of Birmingham. My own experiments, however, do not corroborate the results obtained by these physicians, inasmuch as I have not found it to exercise any influence in diminishing the amount of urine sugar. The curative influence attributed to it is entirely due to the strict diabetic regimen prescribed during its administration. Dr. John W. Ogle has published his experience with it in two cases of uncomplicated diabetes; the conclusion at which he arrived was that it did not produce any real benefit.—*British Med. Journal*, March 8, 1873.

That milk sugar is actually assimilated in diabetes, and consequently is *not* converted into diabetic sugar, has been abundantly proved by my own experiments on a very extensive scale; with a purely skim-milk diet rigidly adhered to in the treatment of the disease, embracing considerably more than *one hundred cases*. The treatment having been continued in different instances over periods varying from a week to three months uninterruptedly, and no other food allowed. The results obtained were the very opposite to that recorded by Dr. Pavy in his single experiment just referred to, in which milk was given together with meat and suet, for a period of only four days, conditions which rendered it altogether valueless as evidence to determine the question.

A considerable number of my experiments have been published from time to time in the 'Lancet' during the last seven years, and also in my separate work on this subject,[1] so that it is unnecessary in the present place to reproduce any of these, or to introduce additional illustrations, especially as the matter will be more fully dealt with under the

[1] *The Skim-Milk Treatment of Diabetes*, London, 1871; also *Trans. of the Clinical Society of London*, 1874, vol. vii.

head of treatment. I may, however, state that *as a very general rule*, a purely skim-milk regimen properly administered either removes the sugar from the urine completely by arresting its formation, or reduces it in a remarkable manner (often from 30 or 40 grains per ounce to a mere trace, or a grain or two); the degree of effect produced depending on the stage of the disease and the presence or absence of complications.

In a few instances amounting to 6 or 7 per cent, which must be regarded as *exceptional* (the patient having been previously on a solid restricted diet) little or no reduction was produced in the excretion of urine sugar beyond the first or second day; in these cases, however, the disease was far advanced with great emaciation and a feeble circulation; they soon came to a fatal termination, even although the skim-milk treatment was withdrawn after a short trial, and the patients allowed a full restricted diet of solid food and stimulants.

In every case, without exception, in which the urine was excessively copious—ranging from eight to thirty-five pints daily—its quantity fell rapidly to six pints, or considerably below this quantity, in the course of twenty-four or forty-eight hours.

But in very few instances, whether the urine was very copious or not, did its specific gravity begin to fall, or the percentage of the sugar it contained begin to diminish to any marked degree before the fifth or sixth day, even in cases in which the sugar entirely disappeared from the urine in the space of fourteen days. It follows, therefore, that no experiment undertaken to determine the action of milk sugar, as a constituent of milk, in diabetes is of any value unless the observation is extended without interruption over ten days or a fortnight at least.

In the next place a purely skim-milk regimen must be rigidly adhered to during the experiment (cream or butter being injurious as will be afterwards shown), while the addition of solid nitrogenous animal food, such as lean beef or mutton, invariably produces a decided and often very considerable rise in the quantity of urine sugar, if the case is severe or considerably advanced. This is an exceedingly interesting fact, of which I have convinced myself by repeated experiments, in relation to the pathology of diabetes.

The discovery by these experiments, that lactose as a constituent of milk is certainly assi-

milated in diabetes, permits of a great revolution and advance in the dietetic treatment of the disease, namely, that notwithstanding the restrictions imposed by Bouchardat, Dr. Pavy, and their followers, a saccharine principle can be taken in large quantities by diabetics, not only with impunity but with great benefit. Because there can be no doubt that a proper admixture of starch or some form of sugar in the food is absolutely essential to the maintenance of health in civilised life, and that the complete withdrawal of these from the diet prescribed in diabetes must be highly injurious. It must be remembered too that lactose in the food of the infant is the analogue of the vegetable starchy and saccharine compounds consumed in more advanced life.

CHAPTER III.

The Relation between Diabetes and the Oleaginous Principles of the Food—Clinical Facts in Relation to the Question—Fat normally absorbed in Diabetes; in excess in the Blood Serum; not deposited in the Tissues in the Disease—The Low Temperature of the Body due to its deficient Oxidation—Fat converted into Diabetic Sugar—Facts illustrative of this—Fat injurious in Advanced Diabetes.

THE question as to whether the oleaginous or fatty principles of the food are in any degree misappropriated and converted into sugar in diabetes, or whether these compounds exercise any influence whatever over its progress or not, seems to have entirely escaped the attention of pathologists. Hitherto it appears to have been taken for granted that these alimentary substances undergo a normal metamorphosis in the production of animal heat and in the process of nutrition, being oxidised and ultimately eliminated from the system in the form of carbonic acid and

water. But when attention is more closely directed to the subject, certain very striking clinical facts are encountered which point strongly to an opposite conclusion.

In the first place, there can be no doubt that the fatty matter so plentifully consumed by those suffering from *advanced* diabetes, when the appetite is inordinate, or even voracious, is digested and absorbed as fully as in health. This is proved by the fact that it produces by its superabundance, for some time after a meal has been taken, a milky appearance of the blood serum which disappears during fasting. This by many has been regarded as peculiar to the disease; it has been described by Dr. Guy Babington[1] and also observed in specimens of diabetic blood 'very strongly marked' by Dr. Pavy,[2] who attributes it to the introduction into the blood of the large quantities of fat consumed by diabetics; but he does not consider this condition to be in any way connected with the disease.

In addition, chemical analysis has shown a great and sometimes enormous increase of fat in

[1] Article, 'Blood,' Todd's *Cyclop. of Anatomy and Physiology.*

[2] Op. cit. 226.

diabetic blood. Thus, Simon[1] found the increase to be (from 1·978 in 1,000, its healthy proportion) as much as 3·640 in one case. But other chemists have detected a much greater augmentation—even to the extent of 6·77 in 1,000 parts of blood. But, of course, the relative proportion of fat in the blood in any case must depend on the stage of the disease, the nature of the food consumed, and the period after a meal at which the blood is examined.

Secondly, although normally digested and absorbed in excessive quantities, fat is certainly *not* stored up in the tissues when the disease is confirmed.

Thirdly, in *uncomplicated* cases of diabetes, even when emaciation is progressing rapidly, there is no increase of heat or febrile excitement, but, on the contrary, a considerable decrease in the temperature of the body, which may fall as low even as 93° or 94°, when the disease is far advanced and severe.

Fourthly, there is in advanced cases, as shown by the experiments of Pettenkofer and Voit, a

[1] Simon's *Animal Chemistry*. Sydenham Soc. ed., vol. i. p. 327.

diminished absorption of oxygen and a correspondently decreased elimination of carbonic acid by diabetics, consuming much larger quantities of food, with a due proportion of fat, than healthy persons. So that, with an increase of combustible matter, there is diminished combustion.

If then, in the advanced stage of the malady, fat is consumed by a diabetic, so much in excess that its absorption renders the blood serum milky, and there is at the same time a great decrease in the normal temperature of the body accompanied by a decidedly diminished absorption of oxygen and elimination of carbonic acid, the question naturally arises, what becomes of all this fatty matter, to what purpose is it applied, and in what form and through what channel does it make its exit from the body?

Surely these data afford very strong presumptive evidence that there must be, under such circumstances, diminished and progressively decreasing oxidation in the system of the fatty principles of the food. Especially when considered in connection with the fact that in the primary stage of the disease, in which the whole of the sugar is formed out of the amylaceous ali-

mentary compounds and the whole of these ingested is converted into diabetic sugar, there is no appreciable decrease in the temperature of the body.

That the temperature does not fall below the normal standard in this stage of diabetes can readily be accounted for by the fact that the loss of vegetable starch and sugar to the system at this period is amply compensated by the supply of fatty matter in the food, even when consumed in moderate and not in excessive quantities, as at a later period of the disease.

In considering this question, it is necessary to attach due importance to the fact that the oleaginous or fatty alimentary principles possess more than double the capacity of starch and sugar as consumers of oxygen and producers of animal heat.[1] It is on this account that the former are

[1] Fat is composed of about 90 per cent. of carbon and hydrogen (79 of carbon and 11 of hydrogen) and only 10 of oxygen. Starch contains 51 per cent. of carbon and hydrogen (45 of carbon and 6 of hydrogen) and as much as 49 per cent. of oxygen. Sugar consists of 49 per cent. only of carbon and hydrogen (43 of carbon and 6 of hydrogen) and 51 per cent., or more than one half, of oxygen.

In fat, which is a *hydro-carbon*, the carbon and most of the hydrogen is *uncombined* with oxygen, and therefore ready for oxida-

so largely consumed by the inhabitants of arctic regions and the latter by those of the tropics; and that there is a due admixture of both in the food of the denizens of temperate latitudes.

It has been urged on theoretical grounds that fatty substances cannot contribute to the formation of diabetic sugar, on the ground that they do not contribute to the production of glycogen by the liver; and because sugar in genuine idiopathic diabetes is always produced by a downward metamorphosis of glycogen.[1] But this argument falls to the ground in the face of the fact, quite recently demonstrated by the experiments of Dr. Salomon, of Berlin, already referred to (at p. 5), showing, in opposition to the conclusion of Dr. Pavy, that fat, even olive oil, is a glycogen-former; thus confirming the opinion previously advanced

tion or combustion, and the production of animal heat. But starch and sugar, which are *carbo-hydrates*, contain oxygen sufficient to oxidise all their hydrogen, leaving their carbon only ready for oxidation. It will therefore be seen how much more powerful the oleaginous alimentary principles are than the amylaceous for the production of heat; this capacity in each class of compounds depending on the amount of carbon and hydrogen they severally contain in the unoxidised state.

[1] These views of Dr. Pavy are supported in editorial articles on Diabetes and Glycogeny in the *Med. Times and Gazette*, May 31 and June 1, 21, 1873.

by Van Deen,[1] Poggiale, and others that glycogen is formed by the liver out of fatty as well as from amylaceous and albuminous materials. It has, moreover, been long established that substances bearing a close analogy to sugar may be obtained by a metamorphosis of fatty matter.[2]

But most assuredly the question as to whether the oleaginous principles of the food really contribute to the formation of diabetic sugar, can only be decided by an appeal to clinical observation and experiment. Consequently, I shall pass from what is hypothetical to the consideration of certain facts derived from this source, which furnish important, and, to my mind, conclusive evidence on the subject; and, first of all, I will direct attention to the experiments which have been made with glycerine, which is the alkaline base of all fats and oils in combination with fatty acids.

Glycerine not being a carbo-hydrate, to which group starch and sugar belong, Dr. Pavy thought

[1] Donders' *Archiv*, 1860, iii. p. 49. Van Deen succeeded by experiments in the laboratory in producing sugar from glycerine through the action of nascent oxygen developed from water by a constant current of electricity.—Todd and Bowman's *Physiology*, 2nd ed., by Dr. Beale, pt. i. p. 138.

[2] Carpenter's *Principles of Human Physiology*, 6th ed. p. 34.

it would not be expected to produce an increased formation and elimination of sugar if administered in diabetes. But on putting it to the test of experiment, the result obtained was exactly opposite to his anticipations. To prevent misrepresentation, I shall quote his own account of the experiment.[1] It is most important to note that his patient was in the advanced stage of diabetes, in which sugar is formed out of the albuminous principles of the food. 'To a patient,' he observes, 'who was being restricted to an animal diet, and who was passing from three to three and a half pints of urine, and from 900 to a little over 1,100 grains of sugar in the twenty-four hours, I ordered glycerine to be administered. Upon the first day he took six ounces; upon the second, eight ounces; and upon the third, ten ounces. The urine rose in quantity to between five and six pints, and the sugar to from upwards of 2,000 to upwards of 3,000 grains *per diem*. The glycerine being omitted, the urine immediately fell in quantity, and averaged for several days about three pints, and the sugar about 1,500 grains. Glycerine was then given again to the extent of

[1] Op. cit., p. 258.

ten ounces a-day for four days consecutively. The urine rose, and upon the third day reached eight pints; and on the fourth day, seven and three quarter pints in quantity. The sugar upon the first day amounted to 3,744 grains; the second, 4,033 grains; the third, 4,608 grains; and the fourth, 4,850 grains.

'The glycerine being now discontinued, the urine on the following day stood at three pints and the sugar at 2,540 grains. The next day the urine amounted only to two and a quarter pints, and the sugar to 1,199 grains. The glycerine employed was that supplied to Guy's Hospital Dispensary.' It is also stated by Dr. Pavy that whatever the explanation may be, the fact is indisputable that the glycerine produced, in addition to the great increase in the sugar excreted in the urine, a material aggravation of the symptoms under which the patient laboured.

This experiment, twice repeated in the same case, and each time with the same result, is certainly most conclusive as to the sugar-forming properties and pernicious influence of glycerine in advanced diabetes. It is further confirmed by the experiment of Dr. Hirschsprung, of Copenhagen,

in the case of the little girl already twice referred to in the present work, in whom glycerine administered for twelve days in succession not only increased the quantity of urine sugar, but also intensified the symptoms of the disease, and made her condition worse than it was before.

And now with regard to fatty substances. Dr. Pavy, in the series of experiments referred to in the preceding chapter, in the case of North, when (February 15) the patient was on a diet composed exclusively of meat, jelly, and beef-tea, and was passing 569 grains of sugar in the twenty-four hours, gave milk to the extent of three pints daily, with meat, instead of jelly and beef-tea, for two consecutive days (February 16 and 17). The result was that the quantity of sugar rose gradually, and, at the end of the second day, amounted to 1,258 grains in the twenty-four hours. During the next three days (February 18, 19, and 20), suet was added to the meat and milk diet; half-a-pound on the first day, three-quarters of a pound on the second, and a quarter of a pound on the third. The effect of this addition of fatty matter was to gradually increase the quantity of urine sugar until it amounted to 2,225

grains in the twenty-four hours at the end of this period. On the following day (February 21), eggs and beef-tea were substituted for the milk, and suet discontinued, and the quantity of urine sugar fell to 927 grains.

In this experiment two facts are obvious: first, that milk, added to the patient's diet, *doubly* augmented the quantity of sugar excreted; and, secondly, that the increase was *quadrupled* by the further addition of suet. It appears to me that the only legitimate interpretation which can be given of these facts is that the special ingredient of milk, which so greatly increased the formation of sugar by the disease, existing as it did in an advanced stage, was butter, and that the further addition of much more fatty matter doubly augmented the evil.[1]

[1] The whole series of experiments, extending over two months, in the case of North, in whom the observation on each particular kind of food or diet, tried in succession, was limited to a period of one, two, or three days at the utmost, give only rough results, and are therefore vitiated and as a whole very unsatisfactory. Each individual experiment should have extended over a much longer period, in consequence of the active osmotic circulation excited by diabetic sugar, and its general diffusion throughout the body and the retention of water in the system (as previously described) thus produced, together with the fact, to which Dr. Pavy himself has drawn attention in the case of starch, that the influence of a par-

Dr. Pavy, however, as already stated, gave a totally different explanation of the result obtained, and attributed the increase of urine sugar to the injurious action of lactose on the disease. But that this conclusion is altogether erroneous, I have shown in a previous chapter. I shall now adduce further evidence of a very decisive character in relation to this question in the two following cases.

The first case was that of a gentleman aged 45, who suffered from severe and confirmed diabetes, of three years' standing at least, attended with considerable emaciation and great debility. He had been subjected to various methods of treatment, dietetic and otherwise, and had lived for several weeks on raw beef exclusively; but it was found that a strictly nitrogenous diet, on this and other occasions, reduced, but did not remove the sugar from the urine. In November 1869, he was living, and had long done so, on a restricted diet,

ticular food in exciting an increased formation of sugar in the disease, may not subside until the lapse of four days or more after its consumption has been discontinued. In all such experiments, a particular kind of food or regimen should be strictly adhered to for not less than a week or a fortnight, or, in some instances, even longer, to obtain complete and trustworthy results.

consisting of ordinary solid animal food, with a moderate proportion of fat and vegetable substances, not altogether free from starch; his beverage was a bottle or more of claret in the day. Under this regimen the urine ranged from four to six pints daily, with a specific gravity varying from 1032 to 1042—never higher; it was loaded with sugar, for the detection of which he had skilfully used the ordinary tests for a long period.

On November 28 he passed four pints of urine, having a density of 1041. On the day following he placed himself on an exclusively milk diet; but he was residing in the country, and took new milk rich in cream and yielded by a particular cow; 'nearly as good,' he observed, 'as London cream.' Of this he took six pints daily, and adhered to it rigidly for eleven days. During this period his urine ranged from four to eight pints, and the specific gravity rose from 1040 to 1046, with a considerable increase in the quantity of sugar.

On December 10 he abandoned the *new milk* diet and resumed his previous restricted regimen; and during the next few days the specific gravity of the urine again fell, and ranged from 1032 to

1038, the daily quantity averaging six pints, with a considerable reduction in the amount of sugar.

It will thus be seen that the formation of sugar by the disease was increased by a milk diet rich in cream.

On April 7 following (1870), this gentleman came under my observation; the disease in the interval having made much progress. On this day he passed nine pints of urine, with a specific gravity of 1045, and containing $14\frac{3}{4}$ ounces of sugar; but on the previous day he had travelled a long distance by rail and taken more starchy food than usual.

On April 8, the day following, I placed the patient on the skim-milk treatment (all other food and drink being prohibited); the cream was very carefully removed from the milk, so that the quantity of fatty matter consumed under the regimen prescribed must have been very small.

On the first day of the treatment the urine fell to four pints and its specific gravity to 1030. On the fourteenth day, April 21st, the urine amounted to five and a quarter pints, its specific gravity being only 1011, and it contained a mere trace of sugar.

On the thirty-eighth day, May 15, I could not

detect the least trace of sugar in the urine. It had completely disappeared, and all the symptoms of the disease except the emaciation had vanished, while the strength of the patient had very greatly increased. The quantity of urine on this day was six pints, its specific gravity 1010; and the quantity of skim milk taken eight pints.

Unfortunately, on the very next day, May 16, the patient of his own accord and without permission swallowed two raw eggs, and four on the day following; the result was that sugar returned in very considerable quantity. This I attributed to the fatty matter of the yolk, and not to the albumen.

Now these experiments on the same individual are to my mind conclusive that fatty substances taken as food increase the formation of sugar in advanced diabetes, and that, when a *milk diet* is given in cases of this class, the increase of urine-sugar or its non-diminution must be attributed to the injurious action of butter and not to the lactose it contains.

I shall, however, give an abstract of another case in illustration, the authenticity of which is beyond doubt, as the patient while under treatment

was examined by several medical gentlemen whose names have already appeared in connection with it.[1]

The patient was a master mariner, who had suffered much from exposure at sea; he was of intemperate habits and broken-down constitution; he had suffered for more than two years from diabetes, which had now assumed a very severe form. When he came under my observation on November 19, 1869, he had for a long time been voiding twenty-seven pints of urine daily on an average, but it frequently amounted to thirty-six pints. This quantity too was exclusive of what was passed in bed involuntarily every night, amounting, as he believed, to three or four pints at least; so that forty pints were often passed in the twenty-four hours. The specific gravity of the urine during this period ranged from 1035 to 1040.

The symptoms of the disease were most severe and caused great suffering, constant and intense

[1] A full history of this case has already been published in my work *On the Skim-Milk Treatment of Diabetes*, p. 210; the results obtained were so extraordinary that I would not have ventured to publish it on my own individual testimony.

thirst, a voracious and insatiable appetite, so that he consumed enormous quantities of food of a nutritious and mixed or unrestricted description, including two pounds of beef or mutton and from *eight to ten pints of the best milk* daily. But he continued notwithstanding to lose flesh rapidly, so that he became very feeble; his sleep was short and broken.

On November 18 he passed twenty-seven pints of urine (exclusive of what was voided involuntarily during the night), with a specific gravity of 1040, and containing thirty-five ounces of sugar, as ascertained by an examination of it on the following day. Consequently, when the daily quantity of urine amounted to forty pints he must have voided three pounds of sugar in the twenty-four hours at the very least.

On November 19 he was placed on the skim-milk treatment (six pints of skim-milk in the twenty-four hours at first), and strictly adhered to throughout; and at the end of twenty-four hours the urine had fallen to four and a half pints, specific gravity 1040. The nocturnal enuresis disappeared on the first night and never again returned, except

on two occasions, slightly, on November 22 and 23.

The treatment was continued and a much larger quantity of skim-milk taken daily. All the distressing symptoms of the disease rapidly subsided; the specific gravity of the urine gradually declined and the quantity of sugar diminished, until December 24, the thirty-fifth day of the treatment, when the urine measured six pints, with a specific gravity of only 1008, and did not contain the slightest trace of sugar.

At this date the patient was restored to a feeling of health and convalescence, although suffering from debility incidental to the emaciation left by the disease; he slept soundly and perspired freely. But he began and continued to improve in strength rapidly, gained flesh, and felt quite satisfied with his skim-milk diet, which was then continued.

On January 3, Dr. A. Wiltshire, of Wimpole Street W., who happened to be in the neighbourhood, at his own expressed request visited this patient at his own house with me, in company with another medical gentleman, and made himself acquainted with the whole history of the case, as already described. Dr. Wiltshire also examined

the patient's urine very carefully, and declared it to be absolutely free from sugar, which had then been absent for ten days.

Dr. Wiltshire suggested that if the patient, now quite convalescent, took new milk containing the cream instead of skim-milk he would most probably gain flesh and strength much more rapidly. At that time I had a strong impression that fatty substances act injuriously in diabetes, but I had no *certain* data to guide me derived from direct clinical observation of my own.[1] Consequently I tried the experiment, and it acted most injuriously.

On January 6 I ordered the patient to take four pints of the best new milk (obtained from a farmer) and an equal quantity of skim-milk daily. The result was an immediate return of sugar in considerable quantity in the urine, together with unequivocal symptoms of the disease. The new milk was continued for four days, and the urine, sugar, and other symptoms, kept increasing, so as to leave no doubt that the butter contained in the cream acted most injuriously.

[1] This was the third case in which I applied the skim-milk treatment.

The patient was now placed a second time on an exclusive skim-milk diet, when the sugar began at once to decrease, and again disappeared from the urine, as well as the other symptoms, at the end of a fortnight, namely on January 23, when the urine measured six pints, with a specific gravity of 1005. But the patient, though a second time convalescent, was much weaker than before, and had lost flesh.

This case, the authenticity or *severity* of which cannot be disputed (and others which will afterwards be cited), is specially deserving the attention of Dr. W. Howship Dickinson, whose treatise on diabetes has appeared while this sheet was passing through the press. In it he makes the assertion, that the same reasons militate against the use of skim-milk as against the treatment of the disease by vegetable sugar, as first suggested by Piorry, which acts so perniciously; and he proceeds to dispose of my own experiments with skim-milk in the following terms, although he has had *no* experience of his own to qualify him to express an opinion on the subject:—

'For diabetes this preparation of milk is doubly unsuited, for it is deprived of the cream

which might in moderation be useful, and it contains the sugar which, in all but the mildest cases, is injurious. If Dr. Donkin be right, much false observation has held its place from the dietetics of Rollo[1] to the pathology of to-day.

I care not for carping, but this I can tell,
We preach very sadly if he preaches well.'

[1] As previously mentioned, Rollo, nearly a century ago, acting on the suggestions of Dr. Francis Home, formulated a dietetic treatment for diabetes. He gave milk with benefit, and prescribed large quantities of fat; but an examination of his two celebrated cases shows that both were in the first stage of the malady, when fat is assimilated. I may here refer Dr. Dickinson back more than a hundred years anterior to the time of Rollo—namely, to the celebrated anatomist and physician Dr. Thomas Willis, to whom he has justly referred as the discoverer of the saccharine character of the urine in diabetes, thus leading the way to a correct understanding of its character. On recently studying Willis's treatise on the disease I was not a little surprised to find a case recorded which he treated successfully by a milk diet, to which white bread or barley was added. Under this diet the urine was rendered saline, and the symptoms of the disease removed three times in succession. This is, so far as I can discover, the first case of diabetes treated dietetically. I shall, therefore, quote in abstract Willis's description of it. Although the effect of food on the disease was then unknown, Willis points out that the chief cause of its recurrence was excess in living.

The case, decidedly a severe one, and graphically told, was that of a nobleman of high rank, great mental endowments, sanguine temperament, florid complexion, and in the vigour of manhood, of whom he says:—'Ad diuresin nimiam proclivis evasit: cumque adeo per plures menses, urinæ profluvium subinde pati solitus

True, Dr. Dickinson certainly does preach very sadly on this subject; and it is equally true that

esset tandem in diabetem (uti videbatur) confirmatam, ac pene deploratam incidit. Præterquam enim quod nycthemeri spatio, urinæ limpidæ, mire dulcescentis et quasi melitæ, fere sesqui congium excerneret, insuper siti immani ac febre velut hectica, cum insigni spirituum languore, virium concidentia, et totius corporis intabescentia afficiebatur.'

It is unnecessary to reproduce Willis's prescriptions, which remind one of the earlier editions of the 'London Pharmacopœia, but the diet of the patient and the results obtained are thus described:—

Diæta fere tantum *lacte*, quod modo crudum, et aqua hordei dilutum, modo coctum, cum pane albo, vel hordeo aliquoties in dies sumebat. Horum usu cum in dies melius habuerit, intra mensem pene sanatum videbatur: quando modice convalescere cœpit, urina insipida liquidi assumpti quantitatem haud multum superabat, et deinceps nonnihil sala, potulentis ingestis copia minor fuit; dein paulatim solito spirituum tenore, et viribus poleus, *ad pristinam diætam redibat.* At vero diathesis in hunc morbum haud ita penitus cessabat quin posta crebra vice, *propter inordinationes in victu*, et forsan ob mutationes circa anni tempora, in recidivam aptus, urinam primo copiosiorem, et dein limpidam, et dulcescentem, cum siti et febricatione, et spirituum languore reddebat. Eorundem vero medicamentorum usu, brevi rursus evadere solebat.

'Non ita pridem, post longius rectæ valetudinis intervallum, paulo antequam urinæ profluvium pati cœperat, magnas in nervoso genere enormitates, et diliquia passus est; viz. in cerebro torporem, et vertiginem, in membris subitos spasmos, tendinum subsultus, quasi venti huc illuc repentis varios transcursus persensit. Deinde cum remediorum idoneorum usu, prædicta symptomata sanari videbantur. Diabetes more solito recrudescebat.

[1] Sub hoc tempore . . . . remediis pene iisdem ac prius utendum præcipiunt, quorum usu cum intra paucos dies melius habere cœperat, aquam calcis vivæ ad uncias quinque vel sex ter in die

since the period he has indicated much false observation and experiment have prevailed, and, I may add, equally as much false hypothesis, to which, as already shown, Dr. Dickinson himself has been by no means an unimportant contributor, on the pathology of diabetes; and now we have another instalment from his pen, affirming the injurious influence of lactose on the affection, founded on incorrect observation, and premises equally erroneous.

Dr. Dickinson is the exponent of a theory (which in a previous chapter I have subjected to an analysis), that diabetes is the result of serious morbid changes in the substance of the brain and chord, which in their character are doubtless irremediable. Consequently every remedy or method of treatment which by experiment can be shown to be capable either of arresting its progress or mitigating its severity must be necessarily repu-

sumendam præscribere, visum erat: quo remedio per quatriduum usus urinam in quantitate modica, bene tinctam, et nonnihil salsam reddebat, et quoad reliqua fere sanus, ubi olim fuerit videbatur.' (Willis seems to have attached undue importance to the lime-water mentioned in the preceding sentence as having been prescribed with the milk diet.)—*Thomæ Willis* '*Pharmaceutice Rationalis*,' Sec. iv Cap. iii.—'*Opera Omnia*,' Amstelædami, 1682.

diated as fallacious; and nothing must be accepted save what can be made *teres atque rotundus*, and moulded into conformity with a preconceived dogma; while every fact which is not sufficiently pliable for this purpose must be summarily rejected. In short, that hypothesis may be placed on a pedestal above the reach of assault, we must needs discard the maxim inculcated by Lord Bacon, that in all scientific investigation the facts of nature must not be twisted and contorted to conform with the preconceptions of a limited intelligence (for the human mind is limited), but on the contrary, the intellect must be expanded to receive the impress of nature as she is found.

I shall merely add to what I have already said on the subject, that Dr. Dickinson's theory is based on data not obtained from a study of the natural history of the disease (if I may so speak), or of the succession of phenomena and events developed during its progress; but solely from anatomical changes detected after death in tissues which have been devastated and disorganised by its ravages. But the attempt to discover the cause and nature of diabetes amongst such materials—and the same observation applies to other wasting

diseases—appears to me to be equally as irrational as it would be to search amongst the smouldering ruins of an edifice for the cause of the fire which produced its destruction.

If necessary, I could adduce much more evidence of a clinical nature to prove that fat taken as food, under any form is, after the lapse of a certain time, converted into sugar in diabetes. But I possess no certain data to show the extent to which this misappropriation proceeds; it is evidently progressive, and very considerable if not well-nigh complete towards the end of the disease, when the temperature of the body falls so low, and it runs its full course.

The exact period, too, at which the saccharine metamorphosis of fat begins must be determined by future investigation. In a previous contribution on the subject, I expressed my belief that it originates at a period anterior to the phase of the disease, in which there is a saccharine transformation of the albuminous principles of the food. But subsequent observation has made me feel uncertain as to the accuracy of this opinion. There can, however, be no doubt that in the first stage of diabetes, when the whole of the sugar is formed

at the expense of the amylaceous alimentary principles, their loss to the system is compensated by the assimilation and oxidation of the fat consumed; so that the normal temperature of the body is thus maintained. But if at this period, when the misappropriation of starch and sugar becomes complete, the quantity of fat taken in the food is insufficient to supply their loss, or, it may be, a portion of it suffers malassimilation also; then the fat previously stored up in the tissues is absorbed and oxidised, so that plump or obese subjects gradually grow thinner and lose weight until the greater portion, or the whole of their fat disappears. Thus Dr. Prout[1] has recorded the case of a very corpulent gentleman suffering from diabetes, who at the commencement of his illness weighed twenty-seven stones, but was in the course of two years reduced to twenty-one stones —having lost six stones in the interval—although at the end of this period he had in a great measure recovered. We can thus readily understand how it is that cod liver oil has been found to act beneficially in the primary stage of the disease, as in the cases recorded by Dr. Beuce

[1] *Op. cit.* p. 30.

Jones[1] and others, by increasing the weight of the body, but without in any degree controlling the progress of the malady. The loss of bulk and weight which occurs at this period from the absorption of fat, must be distinguished from the emaciation incidental to the wasting of muscular tissue in the more advanced stage of the disease, resulting from the misappropriation of the albuminous compounds of the food, aided by that of the fatty. When diabetes reaches this degree of development, neither the administration of cod liver oil nor the consumption of any amount of fatty matter in the food, will cause the deposition of fat in the tissues, and thus add to the weight of the body, or raise and maintain the temperature at its normal degree when it has fallen much below. It is therefore evident that the malassimilation of albumen is accompanied with that of fat. But whether the two conditions are developed simultaneously, or whether the one precedes the other, remains to be determined by future investigation.

In concluding these observations on the rela-

[1] *Med. Times and Gazette*, Feb. 4, 1854; and *Lectures on Pathology and Therapeutics*, p. 71.

tion I have endeavoured to trace between diabetes and the oleaginous principles of food, I shall only further remark, that however harmless or even beneficial these substances may be in the primary stage of the malady, I feel convinced that in its more advanced phase, they contribute powerfully to the formation of sugar, and that their consumption as food in any quantity will render futile any attempt to arrest the disease by dietetic treatment.

CHAPTER IV.

The Relation between the Albuminous Principles of Food and Diabetes—Second Stage of the Disease—Casein—Inanition and Emaciation—Increased Excretion of Urea or Azoturia: influenced by Oxidation of the Tissues and the mal-assimilation of Fat—Symptoms of the Second Stage—State of the Blood—Secondary Affections—Atrophy of the Heart—Death by Asthænia and by Acetonæmia.

THE next phase in the history of diabetes, in which it may be said to have become *confirmed*, is that wherein the albuminous or nitrogenous principles of the food likewise undergo saccharine transformation, to a degree commensurate with the severity and duration of the disease. That such a misappropriation of these principles does take place is a fact too well established to require illustration beyond the cases already referred to in the preceding pages. Indeed, it is this condition which invests the malady with its dangerous character, and engrafts upon it so many serious complications; so that it rarely, if ever, proves fatal

per se until it has reached this, which must be regarded as the *second* or advanced stage of its development.

The transition from the first stage, already described, in which the amylaceous alimentary compounds only are at length wholly converted into diabetic sugar, to the second or more advanced phase, has been traced by accurate observation in only a few instances, owing to the fact that but little special attention has hitherto been directed to the subject, but chiefly to the circumstance that the disease has been but seldom detected until it had reached a period in its progress when (to say nothing of the fatty) the albuminoid substances of ordinary solid animal and vegetable food contribute to the formation of sugar, and are thus more or less misappropriated and rendered unfit for the purposes of nutrition.

Traube traced the development of one case of diabetes, and Dr. Parkes[1] another, in which the formation of sugar from albuminous food was a more advanced condition than that in which it was formed from the amylaceous compounds. In the course of my own experience I have met with a

[1] *Op. cit.* p. 348.

few instances in which the exclusion of starch and sugar for a time removed the sugar from the urine, but after the lapse of a certain period it reappeared in it in spite of this precaution; and undoubtedly, if the history of every genuine case could be traced from its commencement, such would be found to be the sequence of events.

When the albuminous alimentary principles have begun to suffer mal-assimilation, the exclusion of starch from the food merely lessens the quantity of sugar in the urine, but does not entirely remove it.

In this stage of the disease the dependence of the urine sugar on the food is quite as manifest as at an earlier period; it commences to increase shortly after a meal and continues to do so for four or five hours, when it again begins to decline, and may finally disappear altogether from the urine in mild cases, if complete abstinence is adhered to; but in severe instances it merely falls to a minimum, and so continues as long as fasting is practicable. But the quantity of albumen which suffers mal-assimilation gradually increases as the disease advances, until at last it becomes very large. Thus the accurate experiments of

Griesenger have shown that a diabetic restricted to a rigorous meat diet voided in his urine a quantity of sugar equivalent to two-fifths of the entire meat food consumed, or to three-fifths of the albuminous matter contained in the meat.[1] But this does not represent the full degree of misappropriation which takes place when the disease has nearly run its course, and death is impending from inanition.

It is necessary to remark that reference is here made to albuminoid substances derived from the flesh of animals, and to gluten from vegetables, but not to *fresh casein*, which, as will be shown more fully under the head of Treatment, is capable of resisting the mal-assimilating or sugar-forming power of diabetes to a very much greater degree than any other form of albumen. To this fact, for fact it is beyond all doubt, must be chiefly attributed the potency of a purely skim-milk regimen in arresting or mitigating the disease.

I have ascertained by experimental observation in several cases in which the sugar could not be entirely removed from the urine, but simply reduced to a grain or two to the ounce, or even a

[1] *Archiv. für Phys. Heilk.* 1859, p. 53.

mere trace, by a strict skim-milk diet, that the addition of solid animal food, beef or mutton, *invariably* increased the quantity of urine sugar, and frequently to a very considerable degree.

These observations and the facts already stated illustrating the relation between the amylaceous and fatty alimentary principles and diabetes, render it apparent that a period arrives in its course when the only portion of the food consumed by a diabetic, however large in quantity, assimilated and left available for the wants of the body, is a small fraction of the albuminous, and perhaps a little of the fatty; all the rest is changed into diabetic sugar, and cast out of the system as useless and injurious. *Inanition* sets in, the body begins to subsist partly on itself, its temperature ceases to be maintained at the normal standard, emaciation progresses more or less rapidly from atrophy of the muscular tissue, and at last it may become so extreme that, according to the graphic description of Frank,[1] 'Collabuntur tempora, omnisque corporis habitus adeo gracilescit ut nihil ex eo præter cutem et ossa supersit.'

[1] *De curandis hominum morbis Epitome*, 1788.

Intimately connected with the present subject is the excretion of urea, which in confirmed diabetes is always increased in degree varying from a slight excess to as much as double, treble, or even six times its normal quantity, the augmentation being, as a general rule, in proportion to the severity of the disease; this condition has been termed *azoturia.*

The influence of the food, whether mixed or nitrogenous, on the quantity of urea excreted is the same as in health; it begins to increase in the second and third hour, and reaches its maximum in the fourth or fifth hour, when it begins again to decrease.

The large and sometimes enormous quantities of animal food consumed by diabetics is undoubtedly one source of the excessive excretion of urea, but there is another which must exercise a very decided influence in this direction, namely, the wasting of the tissues by their oxidation during the period of inanition and emaciation which must necessarily increase the amount of urea in proportion to the rapidity of its progress, for, as I have already endeavoured to show, the tissues do not

contribute to the formation of diabetic sugar as has been supposed.

The experimental researches of Ranke, and of Bischoff and Voit,[1] on the effect of *inanition* and of different kinds of ingesta on the urine and the elimination of nitrogen, throw considerable light on the phenomena of emaciation and the excessive excretion of urea observed in diabetes. It seems clearly established by these experiments that the quantity of nitrogen or of urea is in *inverse* ratio to the amount of carbon consumed in the food, being most abundant when the *carbonaceous* constituents are absent from the food altogether, and *vice versâ*. Consequently, when fat and starchy matter are either absent from the food, or in quantity insufficient for the maintenance of animal heat, the temperature of the body is maintained by the oxidation or combustion of its albuminous tissues—the muscular tissue especially—and the products of their retrograde metamorphosis. It appears further: when fat is taken in the food, it is consumed by the oxygen, which is thus prevented from oxidising the albuminous tissues. Fat there-

[1] See Dr. Carpenter's interesting chapter on the 'Balance of the Vital Economy,' *Principles of Human Physiology*, 6th ed., p. 324.

fore exercises a powerfully protective influence on these tissues.

Now, in advanced diabetes, the whole of the starch and sugar, and, as I have endeavoured to show, most if not all the fat consumed in the food (together with a variable proportion of the albuminous compounds), are misappropriated and rendered incapable of oxidation, being cast out of the body as a foreign substance. It follows, therefore, that the temperature of the body must be maintained almost entirely by the oxidation or combustion of the albuminous constituents of the food, and of the tissues also, when the supply of the former begins to fail, and that this condition must be productive both of emaciation and of excessive excretion of urea in the urine.

The *symptoms* of the second stage become gradually superadded to the first, and are produced by the greater intensity acquired by the disease. Not only are new symptoms developed, but those pre-existing acquire a much greater degree of severity. Thus the debility, muscular prostration, and loss of nervous energy are greatly increased.

Many grave symptoms referable to the nervous system, and caused by injury inflicted on the brain

and spinal chord, and by their defective nutrition, now make their appearance. Thus, the vision often becomes much impaired (a condition sometimes due to paresis of the ciliary muscle), there is frequently much local anasthæsia in the lower extremities, sleeplessness at night is very distressing, and the intellectual faculties become impaired, the memory grows defective and the mind weak, vacillating, and often fretful and irritable.

If the disease is uncontrolled by treatment the following symptoms are very prominent,—intense thirst with dryness of the mouth and throat, a greatly increased or voracious appetite, increasing emaciation with a fall of the temperature of the body (in uncomplicated cases), and an excessive flow of urine (polyuria) of high specific gravity and strongly impregnated with sugar. These are the most prominent phenomena of the malady when fully developed, and they gradually increase in intensity as it progresses towards a fatal termination.

Thirst or *polydipsia*, often intense and unquenchable, is always present in this stage, and together with a persistently copious flow of urine are generally the first conditions which excite in the

minds of the patients or their relatives a suspicion of diabetes. But as these symptoms are not generally developed in such a degree of severity as to attract attention at an early period, the disease is too frequently not detected until its more advanced or formidable stage has set in, and it has become difficult to control.

The thirst is generally most intense towards evening and at night. Enormous quantities of water are frequently drunk by diabetics without the thirst being in the slightest degree assuaged. In my own experience I have known it exceed thirty-six pints, or four and a half gallons, in the twenty-four hours. But larger quantities have been recorded by other observers. A parched condition of the lips, mouth, and throat, and the unquenchable thirst, with sleeplessness, render the sufferings of the patient still more unendurable; the tongue cleaves to the mouth, and speech becomes difficult.

A dry, harsh, and unperspiring skin is an almost constant symptom of this stage of the malady. But hectic and nocturnal perspiration are frequently present when the disease becomes complicated with pulmonary disease.

An inordinate appetite—*polyphagia*—which is

often voracious, becomes generally developed during this stage of the affection, and is more and more urgent as the emaciation advances, and the mal-assimilation of the albuminoid alimentary principles increases. In short, the greater the degree of inanition created by the disease the greater is the demand for food, and the greater the appetite thereby excited. Consequently, the intensity of the polyphagia is an unerring index of the extent of the mal-assimilation or misappropriation of the nitrogenous substances destined for the nutrition of the body. But, as in the case of thirst, the voracious appetite is often never appeased although enormous quantities of food are taken by the patient. Under these circumstances it is exceedingly fortunate that the function of digestion is generally vigorous and unimpaired, so that quantities of food are digested, which in the healthy subject would produce serious gastric disorder. Indeed, so actively is digestion carried on that the coats of the stomach are frequently found hypertrophied after death. The bowels are usually constipated, and the fæces dry and hard, but diarrhœa often alternates with constipation.

With regard to the polyuria, it may be stated that the quantity of urine voided is subject to great variation, according to the intensity of the disease and the food of the patient; in severe cases it is sometimes enormous, and frequently exceeds thirty pints in the twenty-four hours. In a case of my own, already referred to, it occasionally amounted to about forty pints. When the urine is copious the specific gravity is high, and ranges generally from 1030 to 1045, though a much higher density is sometimes attained. The amount of sugar it contains is also variable, but seldom or never exceeds fifty grains to the ounce, and seldom attains so high a proportion.[1]

A soft, spongy, and bleeding condition of the gums, with looseness of the teeth, is frequently observed; the alveolar processes become absorbed, and the teeth sometimes drop out. In several instances, I have seen this condition cured by treatment, though in some cases the teeth have not been saved.

In the early or middle period of the disease the tongue is frequently covered with a thick coating

[1] It is not intended in the present work to describe the processes for the detection of sugar in the urine.

of fur, but in the advanced stage, attended with much emaciation, it is generally red and devoid of epithelium. A sweet taste in the mouth is frequently experienced, and the breath exhales a sweetish sickly odour which seems to be due to the formation of acetone from decomposition of sugar in the blood. This odour, again to be referred to, is characteristic of the malady, which can generally be recognised by it in advanced cases. In these, too, the lining membrane of the mouth and fauces generally presents a dusky red hue, and often become covered with aphthæ.

The pulse becomes rapid and feeble when the disease is far advanced, and the emaciation considerable.

It is needless to add that with the increasing emaciation the muscular debility grows more painfully distressing.

The condition of the blood in advanced diabetes has not of late received from pathologists the amount of investigation it deserves. As previously stated, it is impregnated with sugar, and contains a great excess of fatty matter for some time after a meal. But it has also been ascertained to be poor and impoverished, as may reasonably be in-

ferred in consequence of the misappropriation of most of the food from which it derives its nutrient materials. It contains more water, and the red corpuscles are greatly diminished, and there is likewise a decrease in the quantity of albumen. Besides, the researches of Pettenkofer and Voit have shown that the blood of a diabetic has not the power of that of a healthy person of absorbing and storing up more oxygen during the night than is required at that period, to be consumed in the daytime.

In diabetes, with an advancing decrease of the body, and of the assimilation of food, there must likewise be a decrease in the absolute quantity of the blood.

In consequence of the impoverished, depraved, poisoned condition of the blood, and the diminution of its quantity, the healthy relation between it and the function of nutrition is abolished. The various tissues and organs are more and more inadequately nourished as the disease advances. A low vitality prevails, a condition of cachexia becomes established, and with it a remarkable proneness to the development of grave secondary affections, many of them of a low inflammatory cha-

racter, by which life is often cut short before the disease has run its full course. It is not within the scope of this work to describe these affections in detail, but I may mention that the most important of them are cataract, carbuncle and carbuncular boils, erysipelatous inflammation, gangrene, bronchitis, pneumonia, and tubercular phthisis (of a form supposed by some to be peculiar to diabetes).

There is one secondary condition of very serious import which gradually creeps on amidst the general ruin and wasting which prevail, namely, *atrophy of the heart*, which is certainly deserving, in a practical point of view, of much more special attention than it has yet received from pathologists.

The subject, however, has not escaped the attention of Sir James Paget.[1] He refers to the case of a woman, aged 22, who died of diabetes, and whose heart, of which there is a drawing in the museum of St. Bartholomew's Hospital, weighed only five ounces.

In this case, Sir James considers the atrophied heart to have been sufficient for the impoverished

[1] *Lectures on Surgical Pathology*, 3rd ed., pp. 86 and 94.

supply of blood, and observes that in such instances there is a uniform decrease of the heart; its cavities become small, and its walls proportionately thin, and that the fat on its exterior diminishes or is changed into a succulent œdematous tissue, whilst in some instances there is dilatation of the cavities which may be the result of wasting in a heart that was once large and strong. Dr. Dickinson[1] refers to the case of a man who died in St. George's Hospital whose heart weighed only 4½ ounces.

Dr. John W. Ogle[2] mentions the condition of the heart in three out of thirteen autopsies after death from diabetes, and in these the heart was softened, or soft, pale, and flabby.

Undoubtedly, the organ becomes involved in the general atrophy of the muscular system; when emaciation is progressing, its propelling power becomes more and more enfeebled, and in consequence of its debility two conditions frequently result, namely, *dropsy* and *death from syncope.*

Dropsy or anasarca frequently occurs in advanced diabetes. Though generally confined to

[1] *Op. cit.* p. 59. [2] *St. George's Hospital Reports*, vol. i.

the lower extremities, it may become so general and excessive as to be the cause of death; and when of a severe character it, as pointed out by Sir Robert Christison,[1] opposes a powerful resistance to remedial measures, and as he justly observes is 'a singular symptom to be found united with diuresis; for it may occur where the patient is passing eight to ten pints of urine daily.' In a case which came under my own observation the patient was voiding, and had done so for a considerably period, the enormous quantity of twenty pints daily, having a specific gravity of 1040.

Several cases have come under my own care, in which the œdema was confined to the lower extremities; but in one the dropsy was general, and proved fatal; in all it was accompanied with great emaciation. In none of these instances was it associated with albuminuria, valvular disease of the heart, appreciable disease of the liver, nor any structural impediment to the venous circulation. In all, the pulse was feeble and frequent, and the anasarca evidently caused by feebleness of the circulation from atrophy of the heart, aided, no doubt,

[1] 'Diabetes,' *Library of Medicine*, vol. iv. p. 253.

as in most other kinds of dropsy, by a poor watery condition of the blood. Its dependence on this cause is well illustrated in the case of one of my patients, a lady beyond the middle age of life, suffering from advanced diabetes of several years standing. She had great anasarca of the limbs, which completely subsided after she had been confined to bed in the horizontal position for a few days during the treatment of a large boil; but it again gradually returned after she left her bed and began to take exercise. I may mention that the anasarca in this case was greatly relieved by treatment; in some others it was altogether removed.

Cardiac atrophy and debility are also productive of exhaustion and sudden fatal sinking, or death from *syncope*, so apt to occur in the advanced stage of diabetes, under any circumstances, but especially so from fatigue and over exertion. Dr. Prout [1] has recorded four cases which came under his observation, evidently fatal from this cause after the fatigue and excitement produced in each instance by a long journey. Thus death by syncope must be regarded as a termination

[1] *Op. cit.* p. 32.

natural to diabetes; it is liable to be produced in another way, namely by restricting the quantity of fluid taken by the patient. Thus Sir Robert Christison observes: 'In the advanced stage the sudden forbearance from the gratification of the thirst, if too long persevered in, is extremely apt to be followed by great and sudden reduction of the urine, swiftly increasing debility, and faintness, a rapid, weak, fluttering pulse, restless expression of the countenance, and great anxiety. It is seldom found practicable to rouse the patient from this condition: and death generally follows in the course of a week.' Such appears to be the effect produced by the retention of sugar in the blood.

But there is another form of fatal termination which is peculiar to diabetes on account of the agent by which it is produced, namely death by coma from *acetonæmia*.

The coma of diabetes has by many been supposed to be produced by the poisonous action of sugar on the brain, because no structural changes are found after death to account for it. But, as has just been shown, the retention of sugar in the blood, or the *surcharge* of the latter with it, affects the circulation, or heart, rather than the brain.

Others again believe the coma to be *uræmic*, from renal disease; but this view cannot be maintained, because it is generally unassociated with any form of kidney affection, as in the two cases about to be referred to. Besides, uræmic coma is usually of sudden invasion, unattended with muscular paralysis, and ushered in and attended generally with *epileptiform convulsions*, so that it has received the designation of *renal epileptic coma*, or *uræmic eclampsia*.

But diabetic coma begins with lethargy and drowsiness, and proceeds on to deep coma, with perfect relaxation or paralysis of the muscular system, resembling narcotic poisoning by opium or the full effect of chloroform. Besides, the breath exhales a powerful and peculiar chloroform-like odour, quite different from that emitted in uræmia. It has been described by Dr. Bence Jones [1] as *acute* diabetes; but the case he has recorded in illustration shows that it was but the abrupt termination of the disease which had escaped detection until considerably advanced, and such is the history of another instance recorded by Dr. Dickinson.[2]

[1] *Op. cit.* p. 52.
[2] *Op. cit.* p. 107.

For a correct explanation of this form of coma we are indebted quite recently to Professor Cantani of Naples, who has shown it to be due to the narcotic action of *acetone*, a volatile chloroform-like fluid, produced by the decomposition of sugar in the blood, or system, in diabetes, under conditions not yet ascertained. This form of blood-poisoning Cantani terms *acetonæmia*, the symptoms of which, in its most severe form, he thus describes:—'In the fourth type of acetonæmia the patient falls unconscious, and *presents all the appearance of being under the influence of chloroform.* There is generally a very strong smell of acetone in his breath and urine; the muscular debility is enormous; the pupils do not act; when the arms are raised, they fall again like those of a dead man; the abdomen is in a state of meteorism through paralysis of the intestines; the renal secretion is suppressed, the mucous membranes become dry; the skin is not acted on by revulsives, or only slightly; the pulse becomes small and weak; and finally death ensues.'

Dr. Berti,[1] from whose contribution to the

[1] I am indebted to a translation of Berti's paper by Dr. A. Henry, in the *London Medical Record*, Sept. 9, 1874.

Royal Venetian Institute of Sciences, this description of acetonæmia by Cantani is quoted, has recorded a case in illustration, of which the following is a brief abstract.

'The patient was a married woman, and the mother of four children, in whom symptoms of diabetes began to appear in June 1873; she was admitted to hospital on the 27th of November, when the following was her condition.

'She was of good physical conformation, but very emaciated and anæmic. The disease appears to have been uncomplicated. She was very weak, had a dry cough, great thirst, polyuria, a very dry skin, excessive appetite, and obstinate constipation there was no disturbance of general sensibility or motility; but she had disordered and double vision, but no impairment of intellect. The temperature was normal. The quantity of urine passed in twenty-four hours was from four to five litres, specific gravity 1060, and contained 50 grammes of sugar per litre. There was no trace of albumen.

'In this condition she remained for four days; but on the night of the fourth day she was found suffering from severe dyspnœa, with dry tongue, flatulence, and pain in the abdomen. The next

morning when seen by Dr. Berti, she lay in a state of profound coma, from which she could not be roused. Now and then she uttered a sharp cry, at the same time carrying the right hand automatically to the head. The eyes were closed, the pupils were dilated and almost insensible to the stimulus of light. Sensation and motion, as well as reflex action, were almost extinguished; the respiration was frequent, difficult, and hoarse. The discharge of urine was completely suspended; none escaped through the catheter early in the morning, but somewhat later about 100 grammes (between three and four ounces) were removed. This contained an abundance of sugar, had no trace of albumen, and under the microscope showed only a few epithelial cells and some blood corpuscles. The patient also exhaled the odour of chloroform.

'Dr. Berti concluded that the case was one of severe acetonæmia. The patient continued in the same state twenty-four hours, and then died. The odour already described became more intense, and at last escaped from the open mouth of the corpse.

'At the necropsy, the sinuses of the dura mater were found to be gorged with blood; there was venous congestion of the meninges; the subarach-

noid space and cerebral ventricles contained serum; there was no apparent change in or near the fourth ventricle. The lungs were congested and œdematous; the apex of the right was scarcely permeable to air. The heart was *small* and contracted; its walls and valves were healthy; the liver was rather hard, and much congested; the spleen was normal; *the kidneys were anæmic, but presented no change of structure;* the bladder had several spots of ecchymosis of various size in its interior. There was nothing remarkable in the other organs. An odour of acetone escaped from all the organs of the body, including the head.

'Dr. Berti sent to Professor Bizio for examination some of the blood from the left ventricle of the heart, pieces of the brain and liver, and one of the kidneys. Distinct evidence of acetone was found in all on the application of chemical tests. Sugar was also found in the blood and in the viscera, the smallest amount being in the brain.'

The following is a case which occurred in my own practice, which I shall describe somewhat fully, as it will be necessary to refer to it again under the head of treatment, as one of the few instances in which scarcely any impression could

be made on the disease and the amount of urine-sugar by the skim-milk treatment.

A spinster lady, aged fifty-five, who had been long out of health, began, early in April 1874, to suffer from unmistakable symptoms of diabetes, namely, from severe and distressing thirst, a dry parched mouth, dryness of the skin, and polyuria; the quantity of urine being from eight to nine pints in the twenty-four hours; her sleep was much disturbed, and her appetite became very inordinate.

Up to this period she had not lost flesh, her weight being 12st. 4lbs.; she was then of stout, tall stature, and in her previous life had been remarkably healthy.

These symptoms increased for a month, when, early in May, it was found that she was suffering from diabetes, and she was placed on a moderately restricted diet, and allowed Hungarian wine and dry sherry. In June she had a severe and protracted attack of diarrhœa.

When she came to consult me on the 4th of November following, and to be placed under treatment in London, she presented the following condition:—Her appetite was very inordinate, and

she was much exhausted after walking exercise and other exertion, and she drank large quantities of hock, which I believe aggravated the disease. At this period she was much emaciated, and had a very gaunt appearance. The skin underneath the chin and over the neck was much folded and wrinkled. She was now much emaciated, and had lost a quarter of her weight (3st. 1lb.), being reduced to 9st. 7lb., during a period of seven months. The urine now amounted to from four to six pints daily, specific gravity 1047, and contained 36 grains of sugar to the ounce. She suffered much from dryness and clamminess of the mouth and throat; but her thirst was much more moderate than at first. Her skin was slightly moist, her appetite very inordinate, there was obstinate constipation; the pulse was eighty-four, and feeble. She complained of great debility and exhaustion.

On November 8, four days afterwards, the patient was placed under the skim-milk treatment exclusively—six pints of skim-milk daily, having a specific gravity of 1037. The quantity of urine collected during the first twenty-four hours was $3\frac{1}{4}$ pints, specific gravity 1035, and contained

23 grains of sugar to the ounce; there being therefore a diminution of thirteen grains to the ounce.

On the second day the quantity of skim-milk was increased to seven pints, to eight on the third, and nine pints on the ninth day (three pints of which were made into curd); this latter quantity was continued for five days. The skim-milk treatment was therefore continued for thirteen days, but during the whole of this period there was not, *after the first day*, any diminution in the excretion of sugar. The urine ranged from 3½ to five pints, with an almost uniform specific gravity of 1035. The amount of sugar excreted was subject to almost daily variation in correspondence with the varying daily quantity of urine; but it always remained considerably below the quantity voided prior to the commencement of the skim-milk treatment. But although there was no progressive improvement in the state of the urine, there was a great amelioration in the general condition of the patient. The distressing dryness of the mouth and throat, and thirst, were entirely relieved; she slept soundly, and was able to walk

very much longer distances with greatly lessened fatigue.

On November 20, the weather being cold, damp, and foggy, she was seized with a bronchitic attack, and on the following morning it was found that the urine had risen to six pints, and its specific gravity to 1040; it contained twenty-seven grains of sugar to the ounce.

I now felt quite convinced, from previous experience, that no impression whatever could be made on the disease by treatment, and I may here remark that *in such instances the end is not far off*. I therefore abandoned the skim-milk regimen. The patient was permitted to drink skim-milk to the extent of three or four pints daily, as she might feel inclined; but she was allowed a substantial meal of soup, roast beef, or mutton, or steak, or chop, with green vegetables, beef-tea, and Hungarian wine; for breakfast she had tea or coffee, brown toast and eggs; and in the evening tea. The thirst and dryness of the mouth now became very distressing, and she was allowed Apollinaris water, with wine, to assuage it.

Under this change of treatment the urine rose to seven and nine pints daily, its specific gravity

varying from 1040 to 1045; the symptoms of the disease became intense, the thirst unquenchable, the nights sleepless, and her strength failed so rapidly that she could not leave her bed.

On the 27th she was much worse; the tongue was dry and brown, the mouth and lips parched with continuous thirst, and there was constant retching and vomiting. No solid food remained on the stomach. Much pain over the region of the liver; bowels obstinately constipated, skin dry, pulse 104 and feeble; no sleep during the preceding night. Urine, nine pints; density 1035; sugar abundant, but not estimated. She was ordered beef-tea in abundance, enemata, and bismuth in large doses and magnesia were prescribed to allay the vomiting. But during this and the two following days she grew gradually worse, and her breath exhaled a strong chloroform-like odour. The urine continued at eight and nine pints, but its specific gravity fell to 1025, showing a great diminution in the quantity of sugar.

On the 29th, towards evening, she became very drowsy, and slept the greater part of the next night. On the following morning she gradually became unconscious; the stupor in-

creased in intensity, the pupils were dilated and the extremities quite motionless and flaccid. The respiration became slower and slower, and she died on the following morning. For the last thirty hours of her life the urine was suppressed.

There was no post-mortem examination of the body; during life there was no albuminuria nor other indication of renal disease. But the abundance of acetone exhaled by the patient strongly impregnated the atmosphere of the apartment during the last four days of her illness.

Acetone is evidently the agent which produces the well-known fetor of the breath so peculiar in diabetes, for this reason, it appears: that the decomposition of a certain portion of sugar is always going on in the system, and that the quantity excreted in the urine does not represent the full amount formed by the disease. The suppression of the urine in the advanced stage of acetonæmia is apparently due to the decomposition of a large quantity of sugar in the blood, and the consequent abolition of its diuretic action.

The conditions which give rise to the formation of acetone in the system are well worthy of inves-

tigation. In connection with this subject I may mention an interesting fact which occurred in the present case, namely, that a new and perfectly clean bottle, well corked, and more than half-full of the patient's urine (having a sp. gr. of 1047, and passed on November 3), was set aside in a closet in a cold temperature, far below that at which fermentation takes place. On withdrawing the cork, which came out with a slight explosion, a few days subsequently, an overpowering odour of acetone was emitted; this substance having been formed by the decomposition of the sugar, which had in this manner completely disappeared from the urine, after escaping the process of fermentation, as shown by the absence of torulæ.

CHAPTER V.

The Dietetic Treatment of Diabetes.—First, Second, and Third Stages: Illustrative Cases.

In most acute diseases there is a natural proclivity to recovery in a large proportion of cases, either through the influence of what has been termed the *vis medicatrix naturæ*, or, more correctly, in consequence of the tendency on the part of these affections, if left to themselves, to run a definite course, then subside, and finally disappear. For this reason it is extremely difficult to determine how far in any individual instance recovery should be attributed to nature, and how much has been achieved by remedies.

But this observation does not apply in the slightest degree to genuine idiopathic diabetes, because with it there is certainly no conservative force of the constitution in operation to check its progress or subdue it; and assuredly it shows no

tendency whatever to end spontaneously in recovery. On the contrary, the disease, if left uncontrolled to pursue its own course, progresses from bad to worse, and at last terminates fatally. This, however, is a fact of very great practical importance, because it enables us to determine with the greatest degree of precision the effect produced on it by different remedial measures, for whenever a decided improvement or recovery takes place such a result must justly be ascribed to the treatment employed against it.

But little requires to be written on the *medicinal* treatment of the disease, inasmuch as it may be broadly stated that almost every known drug has been tried in turn as a specific for it, and found worthless.

In order to ascertain what a vast number of medicinal agents have been prescribed in diabetes from the earliest ages of medicine down to the present time, it is merely necessary to refer to De Ploucquet's *Repertorium*[1] of medical literature, and, since the publication of this most valuable index, to the more important of the numerous contri-

[1] *Literatura Medica Digesta sive Repertorium Medicinæ Practicæ, &c.* Tubingæ, 1808 ad 1814. Vol. i. p. 398 et seq.

butions which have appeared on the treatment of the disease during the last fifty years. It will thus be seen that all the pharmacopœias, old and new, have been ransacked without yielding a single drug, or a combination of such, capable of exercising any marked control over it.

Opium, a very old remedy for diabetes,[1] has been, and by some is still accredited, with a specific action on it; but my own experience, now extending over a quarter of a century, has convinced me that it exercises no influence whatever in arresting its downward progress. In large doses, from one to twenty grains or more, by acting as an anodyne, it often greatly lessens the quantity of urine and the sugar it contains, when the diet is not much restricted; but this effect is produced by deadening the appetite and largely diminishing the consumption

[1] Dr. Dickinson is mistaken in attributing the introduction of this drug as a remedy for the disease to Pelham Warren in the year 1812. In the second century, Archigenes prescribed opium in diabetes, as appears from the following extract from Ætius:—'Porro si prædicta auxilia frustra adhibeantur, affectio ipsa augescat: non absurdum fuerit etiam stuporem inducentibus uti, ita ut soporiferam antidotum papaverum capitibus apparatam exhibeamus, aut aliquem ex dolores levantibus pastillis. Infuso etiam soporifero utendum, velut est *opium* ervi magnitudine cum pari modo Castorei, aut etiam majore.'—*Archigenes apud Ætium Tetrabibli* iii. sermo iii. cap. 1.

of food. Dr. Roberts[1] did not find it produce any reduction in the quantity of urine sugar when the diet was restricted. Moreover, if the administration of the drug is withdrawn, especially when suddenly, the patient relapses into his former condition, and, according to the experience of Dr. Prout, all the symptoms of the disease often return with redoubled violence. The use of opium, in addition, generally produces obstinate constipation and always aggravates it when present; whilst frequently, on account of idiosyncrasy and other conditions prevailing, it cannot be prescribed without discomfort or even injury. Besides, in consequence of its prolonged use, the patient becomes a confirmed opium-eater, and cannot discontinue it. The same observation applies to its alcoloid principle, *codeia*, so strenuously recommended by Dr. Pavy.

I do not wish it to be inferred from these observations that medicinal treatment is useless or unnecessary in diabetes. On the contrary, conditions and complications originate during its progress, both mild and severe, which require to

[1] *Urinary and Renal Diseases*, second ed. p. 254.

be treated on general medical principles. But neither the character nor the variety of these can be anticipated in any individual case; as they originate they must be combated by appropriate remedies.

But experience has fully demonstrated that against the disease itself our only resource is *dietetic* treatment. By this means alone can we expect either to arrest its progress entirely, or to mitigate its severity. Unfortunately this treatment is too often brought into disrepute by the careless, slovenly, and imperfect manner in which it is applied, and, as sometimes happens on account of ignorance displayed by the medical attendant of the patient, not merely of the principles by which it should always be regulated, but even of the merest rudiments of the subject of dietetics.

In considering the dietetic treatment of diabetes I shall exclude all cases of simple glucosuria, whether permanent or intermittent, from deficient assimilation of starch and sugar, occurring in subjects at an advanced period of life: generally traceable to errors of diet, over-indulgence, or sedentary habits. Cases of this description are usually amenable to slight regiminal measures, and are

seldom attended with much derangement of the general health.

It has been already shown that at a period when diabetes becomes confirmed—when it has entered into its second stage—not only the whole of the vegetable amylaceous compounds of the food and the whole or most of the fatty or oleaginous, but also an ever-increasing proportion of the albuminous principles derived from the flesh of animals and from vegetables are misappropriated and converted into diabetic-sugar, and are thus rendered incapable of administering to the nourishment of the body. Consequently, as is well known, a mixed diet, under such conditions, is in the highest degree pernicious, and therefore inadmissible, whilst an exclusive regimen of solid animal food, as prescribed by Bouchardat, is powerless to arrest the disease.

Fortunately we possess two proximate alimentary principles—the one *nitrogenous* or albuminous, the other *carbonaceous* and saccharine—which stand in a widely different relation to diabetes than any other components of ordinary food, whether animal or vegetable. These are *casein* and *lactose*, as they co-exist in their natural condition in milk.

I have already shown that lactose is completely assimilated in diabetes, and does not in the slightest degree contribute to the formation of sugar. The resistance of casein to the sugar-forming process of the malady is not in all cases so perfect as that of lactose, but it is so to a degree immeasurably greater than that of any other albuminous alimentary substance, so that in all but the most severe and advanced or complicated cases it is complete. Consequently, by the exclusive administration of casein and lactose as food, in the form of skim-milk, the excretion of sugar in the urine ceases, and the disease is completely arrested after the lapse of a brief period *in a very large proportion of cases;* and in those instances in which such a completely favourable result is not obtained the formation of sugar is, in all but a few exceptional instances to be referred to, very greatly, sometimes immensely, reduced, and the force of the disease subdued to a degree not to be attained by any other treatment, and, as will be shown, even under the most desperate and hopeless conditions.

The results obtained by my own numerous experiments, corroborated by those of others, have shown that casein and lactose as they exist in

skim-milk exercise a powerfully *curative* action on diabetes; this in the previous chapter I have ascribed not to the lactose but to the casein, to which I shall again have occasion to refer.

For the reasons just stated I have been led to divide the dietetic treatment of diabetes into *three* distinct stages, as follows:—

The *first*, in which by a purely skim-milk regimen the disease is either completely removed or subdued in force; this stage may be termed curative.

The *second* or *transitional*, in which, when the object of the first has been attained, and the patient is convalescent, solid animal and non-amylaceous vegetable food is added to the skim-milk regimen.

The *third*, in which a dietary more or less prolonged, or it may be permanent, must be adopted in order to prevent the recurrence of the disease when it has been cured, or if only subdued, to hold it in check.

Before describing these different stages in detail it is necessary to point out in what manner the skim-milk regimen differs from all previous forms of dietetic treatment, especially from that of

Bouchardat and his followers, who prohibit the use of milk, and of skim-milk especially, by diabetics, but advocate the consumption of fat, oils, cream and butter.

In the first place it differs in excluding as far as practicable the use of fatty or oleaginous substances, which, as I have already shown, are most injurious in advanced diabetes.

Secondly, it ensures the consumption of a plentiful supply, in the form of lactose, of a saccharine principle, so essential to health, which by being converted into lactic acid during digestion is assimilated notwithstanding the disease. In this respect the dietetic treatment of Bouchardat and his followers is deficient to the extent of inflicting injury.

In the first stage of the treatment the patient must be placed on an *exclusive* regimen of skim-milk, or, as I have termed it, the *skim-milk treatment*. It is therefore necessary that it should be known what I mean by this term.

To order the patient to drink as much skim-milk as he can and whenever he chooses, regardless of measure or the time of taking it, or to permit him to partake of other kinds of food in addition,

even in small quantities, is *certainly not* prescribing the treatment.

I have known as much as from sixteen to twenty-six pints of skim-milk swallowed daily by a diabetic, who was thus converted into a species of funnel through the permission of his medical adviser. Of course it was not at all astonishing that this unmethodical but heroic administration of the remedy was *not* crowned with success.

On account of the scrupulous method, perseverance, and self-denial required, this treatment will never be attended with more than partial and infrequent success in hospital practice, unless the patients are placed in isolated special wards, and under the care of strictly trustworthy nurses. Of this I am thoroughly convinced by my own previous experience in hospital practice. All my patients of this class, without exception, in whom the sugar was completely or nearly removed from the urine, began to indulge clandestinely in the most pernicious of the prohibited articles of food, and thus caused a return of the disease. In other cases, again, the treatment could not be carried out in consequence of secret infringement of the rules, which must be *rigidly* enforced. Beyond my own

practice I had an opportunity of observing an instructive instance of this description in Middlesex Hospital, in the case of a patient under the care of Dr. E. Headlam Greenhow—a stout, middle-aged female who had been put under the skim-milk treatment. At first her progress was all that could be desired, but in the course of a few days the quantity of urine began to rise and the sugar it contained to increase considerably; when the clinical clerk, suspecting deception, made a diligent search of her bed, with the result of finding a tea-cake and a quantity of sweets concealed under the mattress, and purveyed to her by her friends. The cause of the increase of the disease was thus readily explained. The same interpretation must likewise be given to a case published by Dr. A. Whyte Barclay,[1] and another by Dr. Pavy,[2] in the 'Lancet,' for the purpose of showing that the skim-milk treatment is injurious, and increases the excretion of sugar—an effect, I may remark, which, so far as I am aware, has never been observed by any but themselves. Both cases were hospital patients, treated in general wards, and were doubtless instances of the deceit, in the matter of food, which

[1] May 24, 1853. [2] June 14, 1853.

diabetics are well known to be so prone to practise, and sometimes with considerable skill.

These observations apply with equal force to the more ignorant and unintelligent of the lower classes treated at their own homes, and to young subjects below the age of maturity, especially females. I fully concur with Bouchardat that this cause exercises a most important influence over the great mortality occurring amongst the latter class of patients.

I do not intend to repeat here the rules to be followed in applying the skim-milk treatment already published in my work on the subject, to which I must refer for fuller information. I shall, however, mention in addition to the *cardinal rule*, that the skim-milk regimen *must be exclusive*: that the quantity of skim-milk—*properly prepared by the careful removal of the cream*—beginning with four, five, or six pints on the first day, must be increased to more or less gradually, according to circumstances, to eight, nine, ten, eleven, or twelve pints in the twenty-four hours, according to the age, sex, size, and condition of the patient. No rule as to quantity can be laid down to suit individual cases; it must be regulated to suit the re-

quirements of each; *but in no instance should it exceed twelve pints.* Not more than seven or eight pints should be taken in the natural fluid condition. When a larger quantity is necessary the surplus should be made into curd by the essence of rennet and taken at separate meals; too much fluid is thus prevented from being taken into the system, while a much larger quantity of flesh-forming material in the form of casein—in combination with salts—is supplied.

In the next place, the skim-milk may be taken cold, or warmed to a temperature of 100° or so, as the patient may desire; *but it must not be boiled;* because a temperature of 212° alters the physical properties of casein, and, as I have found by experience, greatly impairs its therapeutic properties. The specific gravity of the skim-milk used should never be below 1035; that of the best quality is 1040. The daily allowance must be divided into regular meals.

It is necessary to mention that when a skim-milk diet agrees with the patient, as it almost always does with diabetics, it generally produces constipation, which must be carefully remedied by the frequent administration of castor-oil, or of

some mild saline aperient. Attention to this condition is of the utmost importance.

Diarrhœa, though not of frequent occurrence under judicious management, can without much difficulty be remedied by care and attention to the digestive organs, and by the temporary reduction of the quantity of skim-milk, together with the administration of mild astringents. When it proceeds from indigestion, which is seldom the case, I have found the essence of rennet given in half-drachm or drachm doses in a little water immediately after each meal of great service.

A most important feature of the treatment consists in the accuracy with which the daily allowance of food can be measured and regulated from day to day. Besides, instead of being repugnant, and at length, in most cases, intolerable to the taste and appetite of the patient, I have, without exception, found skim-milk highly grateful to diabetics, especially when first administered and the symptoms of the disease are severe, in consequence of their sudden subjugation, especially of the thirst, which is often so very distressing.

When a diabetic, in whom the worst symptoms

of the disease in its fully developed form are severe, is placed on a purely skim-milk regimen, the almost magical rapidity with which they are subdued is almost incredible; twenty-four hours being generally sufficient to produce a marked improvement, and seldom more than from two to six days to obtain complete relief from all suffering except the weakness dependent on emaciation. I have already published numerous instances of this effect, one of which is given at p. 82; but I shall refer to another case to be introduced further on, corroborative of my own experience—that of a soldier treated according to this method in Netley Hospital.

As previously stated, when the quantity of urine is very large it suddenly falls to considerably below the quantity of skim-milk ingested, in consequence of the great diminution produced in the amount of sugar formed and excreted by the kidneys; and *pari passu* the intense thirst and voracious appetite disappear. The skin, previously dry and harsh, becomes moist and perspiring, and many of the symptoms referable to the nervous system are speedily relieved. Profound refreshing sleep succeeds the previously sleepless, restless

nights, almost insupportable by the unquenchable thirst and the urgent calls for micturition. The languor, lassitude, and impaired sensibility of the limbs are also greatly mitigated, and the spirits become buoyant. The patient, whose condition was previously one of intense suffering, expresses thankfulness for the sudden and unexpected change. I may add that this remarkable amelioration is very generally produced even in the most severe and advanced cases, in which the disease has advanced so far and inflicted such extensive injury, both physical and constitutional, that its complete arrest and removal of the sugar from the urine cannot possibly be effected, although immensely reduced in quantity.

The complete removal of the sugar from the urine by treatment in any case must be equivalent to the arrest of its formation in the system, and of the entire subjugation of the disease by which it is produced, especially so when this result is attended by freedom from suffering and a feeling of restored health. The efficacy of any form of treatment in diabetes must, therefore, be estimated by its conjoint influence on the urine and the general health.

If in any given case the sugar continues absent from the urine and health is simultaneously restored, we must regard the success attained to be *complete* and the disease to have been cured, and to remain cured so long as these conditions continue. But if the sugar, even in small quantity, remains permanently in the urine, although a feeling of health may have been restored to the patient, then the success will be only *partial*, although it may be very considerable in degree.

But if no impression whatever is made on the amount of urine-sugar and no improvement in the general health effected, we may with correctness consider the treatment employed to have been useless.

Judging of the efficacy of the skim-milk regimen from this standard of comparison, I have arrived by ample experience at the following conclusions :—

1. That this treatment will *as a general rule* remove the sugar from the urine and completely remove the disease, if the second stage is not too far advanced; the time required to free the urine entirely from sugar varying from twelve days to five or six weeks, the usual period of its removal

being about the fourteenth day. One case, however, has come under my observation in which the sugar disappeared from the urine in three days; in this instance a solid, restricted diet had previously ceased to produce this effect.

2. That if the disease is of long standing and the second stage too far advanced, with much emaciation, and the general injury inflicted irreparable, success will be only partial; in the *majority* of such instances the excretion of sugar will be greatly diminished but not prevented. The progress of the disease will be held in check for an indefinite period, so that patients will acquire a comparative feeling of health and comfort.

These conclusions of course do not apply to cases which are complicated with pulmonary disease and other serious and necessarily fatal affections, although under such forlorn conditions a very extraordinary improvement for a time may be effected by affording relief from the more distressing symptoms.

Although the urine when very copious rapidly falls under the treatment to a quantity which is normal in proportion to the fluid ingesta, its specific gravity seldom begins to decline before

the fifth or sixth day, after which, in successful instances, it rapidly decreases until the sugar disappears entirely from the urine, when it falls as low as 1010, 1008, or even lower.

I have already stated that I have met with a small percentage of cases wherein little or no good was effected by the skim-milk treatment, and in these there was no reduction of the quantity of the urine-sugar beyond the first or second day, after which the specific gravity of the urine continued persistently and uniformly high. Such cases, however, were far advanced, and soon came to a fatal termination, although the treatment was discontinued after a short trial. I have given the details of one of these at page 119. From the experience thus gained I have come to the conclusion that if there is no progressive reduction of the specific gravity of the urine and of the sugar it contains after the expiration of a week (all rules having been strictly observed), little or no good will be produced by the treatment, which may then be discontinued, to prevent it from being undeservedly brought into disrepute; such cases are, except in very young subjects, very far advanced and not amenable to any kind of treatment whatever.

To be effective the treatment must be *applied in time, as well as properly*. In time, I repeat, because there is certainly no other serious chronic malady in which the Hippocratic axiom, *Occasio princeps*, is more applicable than to diabetes, and to secure the timely administration of the remedy a very much closer and attentive study must be directed to the symptoms it presents in the early periods of its progress than they have hitherto received.

Before proceeding to consider the second and third stages of the dietetic treatment, I deem it advisable to introduce a few typical cases illustrative of the preceding observations, in addition to those I have already published elsewhere.

The first case is that of a man treated in Middlesex Hospital by Dr. E. Headlam Greenhow, the following report of which was read by him before the Clinical Society of London, on May 23, 1873 :—[1]

'The patient, W. H., a coal-porter, aged 56, was a large, stout, heavy-looking man, and weighed 15½ stone; he had been of intemperate habits, and subject to rheumatism and winter cough. He was admitted into Middlesex Hospital on November 9,

[1] Trans., 1873, vol. vi., p. 182.

1872, when he was passing a large quantity of urine; the heart, liver, and spleen were healthy, but posteriorly over the base of the right lung there was impaired resonance, and slight crepitation occasionally was heard in the bases of both. The right leg was œdematous, greatly enlarged, and of a purple hue.

'On the day following he was reported to have had a good deal of cough during the night and early morning, and to be expectorating a considerable quantity of frothy muco-purulent sputum containing much black pigment, and this continued more or less during his whole stay in the hospital. He had passed 110 ounces of urine during the twenty-four hours; specific gravity 1035; free from albumen, but giving the reaction of sugar with Trommer's test. He was put on a moderately restricted diet, consisting of lean meat, greens, milk, eggs, and toasted brown bread, with four ounces of brandy daily, and was kept under observation for several days without special treatment. On December 1 he had passed during the previous twenty-four hours 102 ounces of urine, which gave the characteristic reaction for sugar with Trommer's test. It had a specific gravity of 1032,

which fell after fermentation to 1012, showing (according to the results obtained from a series of experiments performed by Dr. W. Roberts) a proportion of 20 grains of sugar to each fluid ounce of urine, or 4 ounces and 2 drachms of sugar in the urine passed during the twenty-four hours. On December 4 he was ordered ½ grain of opium twice a day, and the quantity was increased in the course of two or three days to a grain three times a day. Under the opium he appeared to be somewhat less thirsty, but the quantity of urine did not much diminish, varying from 80 to 100 ounces in the twenty-four hours, whilst its specific gravity ranged from 1030 to 1036. Upon the whole I thought the opium promised to be of some use as regarded the diabetes, but it disagreed with the patient otherwise. His pupils became contracted, his tongue very creamy, and his bowels obstinately confined, with distressing tympanitic distension of the abdomen.

'On December 12, his pulse having become intermittent, the opium was decreased to 2 grains in the day, and an enema was ordered, containing oil of rue, to relieve the abdominal uneasiness.

'On December 13 he was ordered a diet of four

quarts of skimmed milk, without bread or any other article of food whatever, and his brandy was reduced to 3 ounces per day. On this day he passed 95 ounces of urine, with a specific gravity of 1035, reduced by fermentation to 1007. Three days afterwards the opium was reduced to a grain at bed-time, and two days later both the opium and brandy were discontinued. From this date he was kept rigidly on a diet of skim-milk, the quantity being gradually increased up to six quarts, and a portion of it after a time being made into curd. Under this treatment he lost the thirst, his skin became softer, and he perspired at night. He also lost weight to the extent of half a stone, but soon began to regain it, and on December 31 weighed 15 stone 2 pounds. He took no medicine, excepting occasionally a simple cough-mixture, consisting of a solution of acetate of ammonia, ipecacuanha-wine, and compound tincture of camphor, and from time to time he had a dose of castor-oil or a simple enema to move the bowels.

'The quantity of urine passed in the twenty-four hours fell, on December 15, to 60 ounces, specific gravity 1032, reduced by fermentation to 1009; showing 23 grains of sugar per ounce of

urine, the total quantity of sugar excreted during the twenty-four hours being then rather under 3 ounces.

'From this time there was a gradual though not quite steady decrease, both in the quantity of urine passed and in its specific gravity. After January 1 the specific gravity only once reached 1025, and on not more than four occasions exceeded 1,015. The quantity varied more, namely, from 50 to 100 ounces in the twenty-four hours, but was most frequently from about 60 to 80 ounces. On December 28 the urine contained rather less than 5 grains of sugar to each fluid ounce; and the sugar continued to increase, until, on January 7, no sugar was detected, either by fermentation or by Trommer's test. After January 18 no traces of sugar were ever found, except on January 11 and 15. The man was kept in the hospital until March 12, when he was discharged to the Convalescent Hospital, at Eastbourne. His diet then consisted of eggs and bran-gluten cake, with skimmed milk, for breakfast; of lean meat, beef or mutton, and greens, with skimmed milk, for dinner; bran-gluten cakes and skimmed milk for tea; and cold meat with the

cakes and milk for supper. Whilst at Eastbourne he began to eat brown bread, which he still continues to do.

'W. H. was re-admitted into the hospital, under observation, on April 5. He was then passing from 40 to 60 ounces of urine in the twenty-four hours, specific gravity 1010 to 1030. It gave no saccharine reaction, either with Trommer's or the fermentation test, but contained an excess of lithates. He was discharged on April 19, but continues to present himself periodically for examination. He passes during the twenty-four hours from 40 to 50 ounces of urine which remains quite free from sugar. He looks well, and has lost the bronchitis from which he suffered during the first period of his residence in the hospital; but he still complains of some pain in the loins, and says that his right foot swells after any great fatigue. His urine has occasionally been turbid on cooling from excess of lithates, and on a few occasions lithic acid crystals have been found deposited at the bottom of the vessel after micturition.

'The patient attended the hospital May 20, when his aspect was healthy, and he stated that

he was passing from 2 to 2½ pints of urine daily. The specimen he brought was clear, pale-coloured, specific gravity 1013, and perfectly free from sugar when tested with Fehling's and Trommer's tests.'[1]

At the period I am now writing—June 1875, more than two years after the reading of the above report by Dr. Greenhow—this patient again applied at Middlesex Hospital for out-door relief, in consequence of slight cellulitis and abrasions of the surface of the right leg, which still continues in the same swollen, enlarged condition. He was admitted into the hospital by Dr. Greenhow, and kept there more than a fortnight, but without medical treatment, for the purpose of having his urine frequently examined. The result was that during the whole of his stay not a trace of sugar could be detected in it. He was found to be quite free from diabetes, and had been living for the past two years on an ordinary mixed diet, but had given up his intemperate habits.

During the discussion which arose on Dr. Greenhow's paper, at which I was present, Dr. Pavy objecting to the treatment, stated *inter alia* that 'the patient's age was fifty-six, and with such pa-

[1] I must refer to Dr. Greenhow's contribution for the table showing the daily quantity of sugar in the urine from Dec. 3 to March 1.

tients one could do anything.'[1] But against the accuracy of this opinion I must observe that such is by no means the case. In my own experience I have, during the last few years, met with only seven cases of diabetes on which scarcely any impression could be made by treatment, and which soon ended fatally; yet in four of these the disease occurred in subjects between fifty-four and sixty years of age. I have already given the details of one of these in the previous chapter.

That the disease, though not far advanced, was not of so mild a character as was supposed, is shown by the great length of time—thirty-six days—required to remove the sugar entirely from the urine by the treatment; and by the fact that it was not affected by a moderately restricted diet. If the case had been one of simple glucosuria, from deficient assimilation of amylaceous food, as suggested by Dr. Pavy, it would have disappeared within a week.

I brought the following case, which occurred in my own practice, also before the Clinical Society on May 22, 1874[2]—exactly twelve months

[1] *British Medical Journal*, June 7, 1873.

[2] *Transactions of the Clinical Society of London*, 1874, vol. vii. p. 157.

after Dr. Greenhow contributed the above case, the treatment of which by skim-milk began only one day previous (December 13) to that of the present one. But my patient differed from his in being nineteen years younger, and in having been a total abstainer from alcoholic drinks for many years. But the disease was severe, and considerably advanced.

'T. S., a farmer, aged thirty-seven, married, much accustomed to out-door exercise, and a total abstainer from alcoholic drinks for fourteen years, had always been healthy until about seven months previously, when, in May 1872, he began to suffer severely from dryness of the mouth, excessive thirst, listlessness, debility, and great fatigue after exertion; he rapidly lost flesh, to the extent of a stone and a half in a few weeks, and his urine increased in quantity to about six or seven pints daily. In August 1872 he was found to be suffering from diabetes mellitus, and a physician being consulted, he was ordered a restricted diet of beef, mutton, gluten-bread, wheat-meal biscuits, bran-bread, two eggs, and two pints of skimmed milk daily. Under this regimen the symptoms of the disease were somewhat mitigated, but the

specific gravity of the urine continued to range so high as from 1030 to 1050, the daily quantity being from four to five pints. On December 13, 1872, the patient came under my observation, when his urine had a specific gravity of 1040, and contained 25·340 grains of sugar to the ounce. On the day following he was placed under the skimmed milk treatment. At first seven pints, and subsequently eight pints, were taken daily, divided into four meals. No other food was allowed, and no medicine prescribed. At the end of seven days of the treatment the specific gravity of the urine had fallen to 1020, and contained 6·345 grains of sugar to the ounce, there being a diminution of nineteen grains. On the fourteenth day the urine-sugar had fallen to 0·792, or three-quarters of a grain to the ounce. On the sixteenth day of the treatment not a trace of sugar could be detected in the urine, of which the specific gravity was 1012. From that date the urine continued entirely free from sugar. The patient now felt quite well, and free from every symptom of the disease; his strength had wonderfully improved, and the feeling of chilliness, of which he formerly complained, especially at night, had en-

tirely left him. He was ordered nine pints of skimmed milk daily, five or six of which were taken in the liquid state, and three or four in the shape of curd prepared by the essence of rennet. On the thirty-ninth day of the treatment, the sugar having been absent from the urine twenty-two days, the daily allowance of skimmed milk was reduced to one pint, and, in addition to this regimen, he was allowed a half-pound of mutton-chop, with greens, in the middle of the day. This change in diet caused the specific gravity of the urine to rise to 1018 and 1020, but without any return of the sugar. On February 14, 1873, two months from the commencement of the treatment, the patient had regained eight pounds in weight, and a corresponding increase of strength. On April 9 he had gained a stone in weight, and felt much stronger and better than he had done since the commencement of his illness; in short, he was in excellent health and spirits. At this date his urine had a specific gravity of 1020, and was free from sugar; his diet now consisted of about six or seven pints of skimmed milk, with plenty of solid animal food and green vegetables. On February 17 (1874), fourteen months after the

commencement of the treatment, the patient still continued quite well, his urine being free from sugar; he had increased considerably in weight, and for some time previously he had been taking ordinary bread at his meals, and living under very slight restriction as to diet, but still abstaining from alcoholic drinks. He still continues well.

'This was a case of severe confirmed idiopathic diabetes, and pronounced such by his medical advisers, in which a restricted diet, excluding, in a great measure, vegetable sugar and starch, was persevered in for four months, at the end of which period the patient was passing from 2,500 to 3,000 grains of sugar daily, and had received only slight improvement in his condition. But under the skimmed milk treatment the glucosuria disappeared entirely within sixteen days; this effect being followed by a complete restoration of health, flesh, and strength. The patient continued to live by rule, excluding starch and vegetable sugar as much as possible from his food for several months, but taking during this time a large quantity of lactine, or milk-sugar, in the skim-milk. The result was that, within a year after his recovery,

he began to take an almost ordinary diet with impunity. The case had moreover, before the commencement of the treatment, passed into the advanced stage, in which the albuminous constituents of ordinary solid nitrogenous food undergo saccharine metamorphosis. It is in such cases that the superior efficacy of the skimmed milk treatment is so conspicuous.'

I must here add that whilst this sheet was passing through the press—July 5, 1875—I have ascertained that the patient is, and has continued since the date of the above report, in excellent health, being now quite stout and strong. He has, therefore, remained quite free from diabetes for two and a half years, although living during eighteen months of this period on an ordinary mixed diet. His recovery has, therefore, been complete, and so far permanent.

Another very remarkable instance of the efficacy of the skim-milk treatment is recorded in the 'Transactions of the Medical Society of the State of Pennsylvania, U.S.' for 1872,[1] in the report of the President of the Schulkyll County Medical Society. This was kindly forwarded to

[1] Vol. ix. part i. p. 194. Philadelphia, 1872.

me by Dr. Halberstadt, of Potsville, Pennsylvania, treasurer to the society.

'A case of diabetes confined to bed in an apparently hopeless condition from extreme emaciation and debility, was treated by skim-milk, as proposed by Donkin. In ten days the quantity of urine was reduced from *thirty pints* per diem to the normal quantity, and the specific gravity from 1050 to 1023, with a corresponding general improvement in every particular. The patient took seven pints every twenty-four hours, in four meals, and abstaining from everything else, and continued it for four weeks, *gaining fifteen pounds in weight*, when a slight deviation from this diet was immediately followed by a return of the glycogenic symptoms. The milk treatment was then continued for four months, when it was found that broiled beef and mutton, with bran bread, could be taken without detriment, and at the end of five months no trace of sugar could be discovered. At this period his condition was such as to enable him to endure considerable fatigue and to embark in business—a matter which, before he began the exclusive milk regimen, he and his friends had for ever abandoned in his case.'

Dr. J. W. Agnew, of Hobart Town, Tasmania, has also contributed to the 'Lancet'[1] a very successful example of the treatment in the case of a patient suffering from diabetes in a severe form, for the particulars of which I must refer to his contribution.

In these cases the success of the treatment was complete. I shall, therefore, now cite two typical instances to show what can be accomplished under much less favourable, nay, desperate conditions when the disease is too far advanced to permit of complete recovery. They demonstrate, moreover, in the most conclusive manner, that the skim-milk treatment is capable, under such circumstances, of reducing the quantity of urine-sugar to a very much greater degree, and of holding the disease in check far more powerfully than any other remedy yet discovered; to say nothing of the subjugation of the more distressing symptoms.

In the following case,[2] a diet restricted (except the lactose of milk) to purely nitrogenous substances, was subjected to a lengthened trial in the

[1] January 3, 1874, p. 40.

[2] Published in the *Lancet*, Jan. 18, 1873.

first instance, and then an exclusive regimen of skim-milk. The two forms of treatment were thus tested by a most carefully-conducted experiment.

'W. B——, aged sixty years,[1] lost his health two years ago, when he was obliged to give up work, and began to lose flesh and weight rapidly (his weight at that period having been 15st., but now reduced to 8 st. 13 lb., showing a loss of 6 st. 1 lb. up to the present time). At the commencement of his illness his appetite greatly increased, and he began to suffer from excessive thirst, great debility, and loss of muscular power, a greatly increased flow of urine, and a dry skin. These symptoms have since gone on gradually increasing. The large flow of urine induced him to remark to his medical attendants that his blood was going to water, but still the disease remained undetected until it was recognised by another practitioner in April 1872, or eighteen months after the health of the patient broke down. When closely questioned on the subject the patient stated distinctly that long prior to the period he

[1] This case is another instance of the frequent severity of the disease in advanced life.

fixed as the beginning of his illness (when he could no longer work) he suffered much from debility, weakness of the limbs, and general indisposition. The disease, therefore, as usual, appeared to have come on insidiously, and to have had its origin at a date long anterior to the period when it became so fully developed as to cause a complete breakdown of the patient's health, and the accompanying great emaciation and other distressing symptoms indicative of an advanced stage of the malady.

'When I first saw the patient, on August 10, 1872, he suffered from the symptoms just enumerated, and complained much of weakness and diminished sensibility of the limbs and loss of sensation in the feet, almost complete in the soles, so that his gait, with the assistance of a stick, was very unsteady. For months previously he had confined himself to a diet consisting of 1½ lbs. of beef or mutton, green vegetables, a moderate quantity of ship-biscuit, and a quart of milk daily; he also drank water. He was passing from 8 to 9 pints of urine, having a density of 1040, and (on August 10) containing 31·247 grs. of sugar to the fluid ounce.

'He was now placed on a restricted diet, consisting of 1 lb. of lean chop or steak, taken at breakfast and dinner, three or four pieces of gluten-bread, and from seven to eight pints of skim-milk daily. All saccharine and starch matter (except the lactine of skim-milk) and fat in a great measure were thus strictly excluded. This regimen was strictly adhered to for a period of nine weeks, but with only slight improvement in the condition of the patient, so that on October 12 he was voiding 7½ pints of urine, specific gravity 1038, and containing 25·340 grs. of sugar to the fluid ounce.

'He was now subjected to an exclusive skim-milk diet (nine to ten pints daily, three pints being made into curd, and taken at three meals). The following table shows the result on the disease, as revealed by the rapid and remarkable diminution in the quantity of urine-sugar. I must add that the quantitative estimation of sugar was made by the beautiful polarising saccharimeter of Soleil, perfected by the manufacturer, Duboscq, of Paris, by which the most exact results are easily obtained :—

Diet restricted to meat, gluten-bread, and skim-milk, end of ninth week	Pints of urine daily	Specific gravity	Grains of sugar per fluid oz.
October 12 . . .	7½	1038	25·340
Exclusive skim-milk diet, begun 12th October			
October 16 . . .	6	1030	19·797
,, 22 . . .	6	1021	12·670
,, 26 . . .	6½	1015	7·419
,, 30 . . .	6½	1020	9·502
November 1 . . .	5½	1020	10·294
,, 4 . . .	6	1015	7·127
,, 8 . . .	5	1012	2·771
,, 12 . . .	5¼	1007	1·583
,, 18 . . .	4¾	1010	2·375

'It will thus be observed that in the space of thirty-six days the skim-milk treatment gradually reduced the quantity of urine-sugar from 25·340 gr. to 2·375 gr. per fluid ounce of urine—a diminution equivalent to 22·965 gr. per ounce—and at the same time decreased the daily quantity of urine to the extent of 2¾ pints.

'This case is extremely valuable in demonstrating, in the clearest possible manner, the fact that *skim-milk loses its curative power altogether, and becomes valueless as a remedy, in diabetes, when administered in combination with solid animal or other nitrogenous food.* I have repeated the experiment over and over again, with every variety

of modification, in similar cases, and always with the same result.

'I may add that the improvement in the general health of the patient, and in the more important or distressing symptoms, especially in the loss of sensation in the feet and legs, was quite commensurate with the decrease of the urine-sugar. He became able to walk steadily and with a firm step.'

The patient was now placed a second time on the same restricted diet of meat, gluten-bread, and skim-milk, which he took previous to October 12, and at the end of a week the specific gravity of the urine rose from 1010 to 1035, and the sugar to above 22 grains to the ounce. Lactic acid, in the fluid condition, to the extent of half an ounce daily in four doses, diluted with water, was now given with the same diet for a period of ten days, but without producing any beneficial effect. At the end of this period he was much worse, and the quantity of sugar increased to 25 grains to the ounce of urine, which had risen considerably in quantity. I now resolved to place the patient a second time on the skim-milk regimen, and the result

was that the urine-sugar again fell to below 3 grains to the ounce within a fortnight, with a great improvement in his condition in other respects.

This experiment, and others which I have since tried, have convinced me that lactic acid exercises no curative action in diabetes.

Cantani introduced the lactic acid treatment[1] on purely theoretical grounds, in adopting the opinion of Reynoso that diabetes depends on defective combustion, and not on increased production of sugar: a theory altogether irreconcilable with the well-known clinical fact that the formation of sugar by the disease is, in severe cases, so abnormally excessive that all but a small fraction of the large quantities of food generally consumed is transformed into it, so that in such instances sugar is excreted in the urine sometimes to the extent of $2\frac{1}{2}$ or 3 pounds daily, a quantity enormously beyond the requirements of the system in health.

But if lactic acid possesses any curative action over diabetes, which I do not believe, the merit of having discovered it would belong to myself in having anticipated Cantani by the introduction of the skim-milk treatment, by means of which an

[1] On this subject see foot-note, p. 62.

abundance of lactose is administered, which, becoming changed into lactic acid, supplies the system with it in very much larger quantity than prescribed by him.

Dr. G. W. Balfour, of Edinburgh, who is the chief advocate of the lactic acid treatment in this country, certainly overlooks the fact that Cantani combines the administration of lactic acid with a nitrogenous animal diet even more rigorous than that of Bouchardat. It is certainly to this circumstance that the success obtained in his cases is attributable.

An examination of Dr. Balfour's cases[1] likewise shows that the treatment is valueless unless the patient is restricted to a strict meat or skim-milk diet. He mentions that bran biscuits are inadmissible in the early period of the treatment.

The following case, which is a very striking illustration of the beneficial effects of the skim-milk treatment under the most hopeless circumstances, has been recorded by Dr. W. J. Fyffe, Surgeon-Major, and assistant Professor of Medicine, Army Medical College, Netley:—[2]

[1] *Edin. Med. Journal*, December 1871, and September 1874.

[2] *Army Medical Report* for 1871, p. 278 (Appendix No. ix. *Army Blue Book*).

'*Case of Saccharine Diabetes treated by the administration of a purely Skim-milk Diet.*

'Private H. H., 25th Regiment, æt. 26; four years' service; served three years in India, where he suffered from liver complaint. On the voyage home, in March 1871, he was attacked with symptoms of diabetes. He was admitted to Netley Hospital on the 8th April. He was then passing about fifteen pints of urine daily, containing a large quantity of sugar, with a specific gravity of 1030. He was emaciated and very weak. He was placed on a diet composed principally of fish, fresh mutton, bran-biscuits, and a small quantity of milk. With occasional variation he was kept on a diet of this kind for three months. The mineral acids were prescribed, and opium occasionally administered. There was, however, no improvement. The quantity of urine now passed was undiminished, and the patient had become so weak that he was unable to leave his bed.

'It was now determined to give a trial to a purely skim-milk diet, as recommended by Dr. Donkin. He was placed on four pints of milk

per diem, to the exclusion of everything else. This was on the 14th July. On the 15th, within twenty-four hours, the quantity of urine passed fell from thirteen pints to nine. The skim-milk was now increased to eight pints daily, and finally to nine pints, divided into four meals. On the 18th July, three days after the milk treatment was commenced, the quantity of urine passed had fallen to five pints fourteen ounces. On the 19th he passed four pints fifteen ounces; on the 24th three pints; on the 31st two pints. He remained in the hospital until the 18th August, and the quantity of urine passed daily did not then exceed two pints seven ounces.'

Although the sugar was not completely removed from the urine, nor the disease altogether arrested, the effect produced by the treatment is thus described by Dr. Fyffe:—

'The general health of the patient improved immensely after he had been taking the milk for a few days; he felt stronger and better than he had done for months; he lost the feeling of lassitude and *malaise* which he had before experienced; he was able to leave his bed and walk out for exercise in the hospital grounds. The

intense thirst which is so distressing in these cases was allayed. His nights were quiet and peaceful; instead of having to empty his bladder five or six times during the night, he had only to do so *once*. The voracious appetite which he could scarcely satisfy, even when taking large quantities of animal food, no longer consumed him; his weight increased by about 7 lbs., and his spirits, which were of the lowest, became bright and cheerful, and he acknowledged the comfort and benefit he had derived from the milk treatment.

'In this case there was no difficulty in giving the milk until the patient had been taking it for more than a month, when he began to get tired of it, and craved for other food; but his desire to recover kept him from transgressing the rules. He was discharged from the service at the end of August, greatly improved in health. Whether he has adhered to the injunctions given him with regard to diet I cannot say.'

I am indebted to the kindness of Dr. Fyffe for having directed my attention to this case; at the same time he informed me that he had found the treatment equally beneficial in two

other cases in Netley Hospital; and I gladly avail myself of his testimony to show how much good can be accomplished by it, even under the most desperate and hopeless conditions. Dr. Fyffe stated, in addition, that the skim-milk treatment of saccharine diabetes had given him more satisfaction than any other treatment he had ever attempted in the management of this disease, and that two facts had impressed themselves on his mind after observing the effects of it: 'first, the *rapid* diminution of the quantity of the urine passed in twenty-four hours; secondly, the *rapid* improvement in the general condition of the patient.'

This case is an excellent illustration of the greatly increased or rapidly acquired strength which is experienced under the skim-milk regimen after the sugar has been greatly diminished and the other symptoms allayed. So great is the improvement in this respect, that in some cases which I have already published, patients after having lived exclusively on skim-milk for five or six weeks have walked six or seven miles without fatigue, who previously were quite incapable of walking more than a quarter of a mile without

rest. This sudden restoration of strength has often created astonishment in the minds of relatives and of the patients themselves, who were previously prejudiced against the treatment. To what, then, is this to be attributed, for I have often observed it in emaciated subjects, in whom, for the time being, there was no such increase of flesh and weight as in Dr. Fyffe's case? The sudden removal of the saccharine impregnation of the blood and tissues must undoubtedly exercise considerable influence in producing it. But it seems to me to be chiefly due to the great improvement effected in the condition of the blood by the assimilation of so much food (*carbonaceous as well as nitrogenous*), and the restoration of its function of absorbing and storing up oxygen at night *during sleep*, to be consumed in exertion during the day, this important function being abolished, or nearly so, in advanced diabetes, as shown by the experimental researches of Pettenkofer and Voit, previously referred to. The restoration of this power to the blood and the complete assimilation of so much oxidisable material in the form of milk-sugar must of necessity be

productive of increased oxidation, previously reduced far below the normal degree.

It will also be observed that Dr. Fyffe's previously bed-ridden patient, in addition to this speedy increase of strength, *gained seven pounds in weight.* This increase of flesh and weight, moreover, was acquired through the agency of that which Dr. Dickinson terms 'a fallacious remedy,' 'a course of starvation,' injurious in all but 'exceptionally mild' cases, namely, skim-milk.

I have already fully refuted Dr. Dickinson's *groundless assertions* that the treatment is either fallacious or injurious. I shall, therefore, in the present place, as fittest for the subject, offer a few remarks to demonstrate the fallacy of the opinion that a skim-milk diet is a starvation treatment. To rebut this objection—which, I may observe, is the one *vulgarly* entertained by the uneducated in all that pertains to the subject of dietetics—it is only necessary to point to *facts*, 'open, palpable,' obtained by *direct experiment*, as in the above case, and those preceding it, recorded in the present work, as well as others published elsewhere. But the objection can also be disposed of on purely physiological grounds. This question brings us

to the consideration of casein of milk as an article of food.

On this subject I must premise, without reproducing here what I have written elsewhere on the subject of milk, that the specific gravity of the best skim-milk (cow's milk), from which the cream has been carefully separated, is, as I have ascertained by an examination of innumerable specimens in the country, from 1035 to 1040. This density is, therefore, from 5 to 10 degrees higher than that of milk itself, and also of the blood serum, which supplies the tissues of the body with the materials for their nutrition and the glands for their secretions.

Skim-milk contains relatively more sugar and casein than entire milk. A pint of the best skim-milk contains an ounce of milk-sugar, of which, therefore, as much as from 6 to 8 or more ounces can be given daily to a diabetic; the whole being assimilated.

A pint of the best skim-milk contains at the outside not more than five ounces of water in an *uncombined* condition. *The remaining* 15 *ounces, by measure, consists of casein in a fluid, coagulable state,* which contains almost identically the same

quantity of water *in combination* as beef and mutton, namely, 72 per cent. A pint of the best skim-milk, therefore, contains 15 ounces of casein, which is fluidised muscle, brain, nerve, bone, and everything else of which the human body is composed. Consequently, by giving a patient from 8 to 12 pints of skim-milk daily (part of it being in the form of curd), a larger quantity of nitrogenous or flesh-forming food is consumed than can be taken in almost any other form.

When a person takes a full meal of beef or mutton, with bread and vegetables, he is obliged to drink a considerable quantity of water; so that such a meal after digestion does not yield, if fat be excepted, a chyme or chyle richer in solids than one of skim-milk to which nature, if I may so speak, has added exactly the requisite quantity of water. Certainly there is no subject concerning which at the present day so much ignorance and prejudice prevails—even amongst the educated classes, professional and non-professional—as with reference to milk as an article of food.

Casein is an albuminous compound, the composition of which and the changes it undergoes

during digestion have not been sufficiently studied; it is a primitive form of albumen formed in the laboratory of nature to afford nitrogenous and saline materials for the development of the body of every young mammal (however diversified its habits and the nature of its food may be in adult life) at a period of its existence when the function of digestion is most imperfect, and yet the growth of the body most rapid and the function of nutrition most actively and healthfully carried on. It is, therefore, perfectly rational to assume, if we believe in a Creator and in an infallible design manifest in nature, that casein must be better fitted to accomplish this end than any other alimentary substance.

Casein holds in intimate combination the salts which enter into the composition of all the tissues of the body, and it is especially remarkable for the large quantity of the phosphates it contains, especially the phosphate of lime, which is a constituent of every tissue.

When the treatment has been successful the patient should continue the skim-milk diet rigorously from a fortnight to six weeks after the disappearance of the sugar from the urine, in order

that convalescence may be confirmed and the danger of a return of the disease avoided. The *second stage* of the treatment should then be commenced.

In this stage—which, as I have stated, is transitional, and precedes the period when a more permanent regimen can be prescribed—the quantity of skim-milk, if previously large, must be reduced and more of it taken in the form of curd (which can be made very agreeable by the use of 'seasonings'), and, *in addition*, one or two moderate meals—according to the condition of the patient—of lightly-cooked *lean* chop or steak, or of roast mutton or beef, with *green, non-starchy* vegetables, must be prescribed. The vegetables to be allowed are *spinach, lettuce, endive, mustard-and-cress, watercress, the young leaves of the nasturtium, the green leaves of scallions, the tops of radishes, greens, turnip-greens, French beans and scarlet-runners in a very young condition before seed is formed.* This catalogue embraces almost all vegetable articles of food *not* strictly forbidden as highly pernicious at this period of the treatment.

Beef-tea, and mutton-broth from which the fat has been removed, after cooling and without barley or vegetables, except the green leaves of

the leek, may also be taken in moderate quantity once daily.

During this period of the treatment, which requires the utmost care and nicety, the urine must be tested daily; and, should the smallest portion of sugar be detected in it, the quantity of solid animal food must be diminished and the skim-milk increased for a while, and a greater restriction also placed on the vegetable articles of food, and greater care bestowed on their selection.

Should the patient, under the regimen thus defined and varied as much as its limited resources will permit, progress favourably, and the urine continue free from sugar, fish may be allowed at the principal or dinner meal, which should be early; but the species selected should be *cod*, *ling*, *whiting*, *haddock*, and *skate*, which contain no fat except in their livers, which must be avoided. Salmon, salmon-trout and herrings are very oily fish, and must be forbidden; and so also oysters, the livers of which are rich in glycogen.

After what has already been stated it is superfluous to repeat that all fatty or oleaginous substances and all vegetable articles of food and

drink containing starch and sugar must be avoided with the most scrupulous care, because an indulgence in them *at this particular period will generally cause a return of the disease*, which, when thus re-induced, frequently assumes an intractable and virulent form.

The chief articles of food thus prohibited are —Of the *oleaginous: fat, oils, bacon, pork, butter, cream, milk, cheese,*[1] *and the yolk of eggs.* Of the *amylaceous: bread, white or brown; pastry of every description, flour, and all articles of food, such as soups, into which it enters; maccaroni, vermicelli, rice, sago, tapioca, arrowroot, peas or pea-meal, beans or bean-meal, Indian corn flour, potatoes, full-grown French beans and scarlet-runners, turnips, carrots, parsnips, artichokes, cauliflower, cabbages, Brussels sprouts, asparagus, seakale, cucumber, vegetable-marrow; all kinds of fruit in any form, except olives in pickle.*

To this list must be added all saccharine drinks, namely, ale and beer, stout and porter; and all wines containing sugar, more especially

[1] I have put cheese, even Dutch cheese made from skim-milk, to the test of direct experiment, and find that it increases the quantity of urine-sugar.

port, sherry, and hock as it is found in the English market especially.

Alcoholic stimulants should be avoided if possible; yet in certain cases, though not often, they are required; whilst in others, from long-continued habit, the patient cannot possibly discontinue their use altogether. Spirits as a rule are objectionable, but, if permitted, the best form is French bottled pale brandy or the purest Scotch whisky. The best alcoholic drinks for diabetics are French wines, especially the different kinds of claret of good quality; also the red Hungarian wines.

I am in the habit of allowing a breakfast cupful of tea or coffee (without sugar, of course) in the morning and evening, or Cadbury's essence of cocoa, which is free from fatty matter; these beverages are very refreshing to those patients especially who are not allowed stronger stimulants.

From the commencement of the treatment, if the season permits and the weather is mild and genial, I prescribe exercise in the open air, on foot, and even on horseback, if the patient is sufficiently strong. To those who have the

opportunity, working in a flower-garden is a very agreeable and beneficial recreation, and so also is angling in localities where too much exertion is not required, and the patient is sufficiently convalescent.

Vicissitudes of temperature must be carefully avoided, on account of the injurious effect of chills; and during cold or damp weather the patient must be confined to the house. In autumn, winter, and spring warm clothing must be worn; in summer the dress should be light, but of warm material, with flannel next to the skin, to prevent any injurious effects resulting from perspiration.

The period over which the second stage of the treatment must extend is subject to great variation, and depends on the conditions pertaining to individual cases; more especially on age, idiosyncrasy, and the degree to which the disease may have been developed before the patient was placed under treatment. In some instances it may be limited to a few months, in others a very much longer period will be required before a greater variety of food can be indulged in without a recurrence of sugar in the urine and of the disease.

The third stage, in which a more permanent dietary is prescribed, should be gradually developed out of the second by the addition of a much greater variety of animal and vegetable food.

Thus, milk may be substituted—in part, at least—for skim-milk, should the patient prefer the change; and a moderate quantity of fatty food, including butter, may be taken, with the exception of pork, bacon, and cheese, which are very unsuitable for diabetics.

The articles of food to be permitted—in addition to beef, mutton, and other kinds already mentioned—are lamb, veal, tongue, ham, chicken, turkey, game, eggs, all kinds of soup not containing flour or starchy vegetables, fish of every variety, lobsters, crabs, shrimps, and oysters.

All kinds of *green* vegetables may also be taken, including asparagus and full-grown (marketable) French and scarlet-runner beans.

This dietary permits of great variety, and is most generous, containing as it does all the proximate principles of food and everything else requisite for the healthy nutrition of the body.

But after complete recovery, in a large majority of cases, a most careful avoidance must be practised of the more starchy articles of ordinary vegetable food, such as bread, pastry, and all substances into which flour enters; potatoes, peas, beans, carrots, turnips, Indian corn flour, and rice —to say nothing of sago, arrowroot, and tapioca, which consist of starch. This restriction applies equally to sugar in any shape or form, whether existing in solids or in liquids.

Indulgence in any of the prohibited articles of food or drink—at least before a long and indefinable period has elapsed after convalescence —will almost certainly be followed by a return of the disease, as I have said, in the majority of instances. And when the malady is so re-induced it is generally of a much more intractable character than on its first invasion.

The fact should always be clearly explained to those who have recovered from an attack of confirmed diabetes that, on account of *idiosyncrasy*, a strong tendency to a return remains behind, to prevent which it is absolutely essential that they should continue to live by the rules prescribed for them —each individually—in the avoidance of all kinds of

food and drink, and mode of living, which act perniciously and are prone to re-induce and re-establish the disease. With them, as a rule, a cure is altogether *conditional*: they may continue free from the malady and in the enjoyment of health so long as they curb their appetite and inclinations, *but no longer*. The pleasures of the table must to a great extent be abandoned, and, instead, a simple, nutritious, and at the same time agreeable regimen adopted.

It is certain that an amylaceous alimentary principle, such as is abundantly supplied by the vegetable substances prohibited above, is essential to health, under civilised conditions, and that the complete absence of such from the food, for a lengthened period, is incompatible with health. Fortunately, milk supplies a principle of this class in the lactose it contains, which, as I have already shown, can be consumed by diabetics in any quantity with benefit instead of injury. It follows, therefore, that by allowing skim-milk to enter largely into their dietary a perfect substitute is thus provided for the prohibited articles of vegetable food. The gluten and starch which these contain are chemically and physiologi-

cally the analogues of the casein and lactose of milk.

The prohibition of bread from the regimen thus prescribed is generally complained of as the greatest hardship to be endured; consequently, various substitutes have from time to time been invented. Thus we have the gluten-bread first suggested by Bouchardat, and the bran-biscuits made according to different formulæ. The former, however, is insipid and unpalatable, while the latter, when free from starch, are composed entirely of *lignine*, and therefore contain *no nutriment whatever*. To obviate these serious objections, it struck me that a very important end would be gained if a kind of diabetic bread could be manufactured consisting of an admixture of gluten and bran. I therefore communicated with Mr. Van Abbott, of Princes Street, Cavendish Square, on the subject, and he has succeeded in getting manufactured in France, after much difficulty, a bread consisting of 80 per cent. of gluten and 20 per cent. of bran, nearly free from starch, and a very small quantity of butter. This bread is a much closer approximation to ordinary brown bread than any other substitute now in use. It is

not only agreeable and palatable to the patient, as well as nutritious, on account of the large proportion of gluten, but, what is also very important, it excites the peristaltic action of the bowels and prevents or corrects constipation, in consequence of the *lignine* it contains in the form of bran. I consider this bread to be much superior to any other form hitherto produced for the use of diabetics.

There can be no doubt whatever that a long holiday, with plenty of exercise, under a genial atmosphere, with change of scenery and complete relaxation from business, contributes powerfully to confirm the health of those convalescent from the disease.

I am the more anxious to direct attention to this circumstance, having ascertained by experience in many cases that hygiene and relaxation from business or professional pursuits for a considerable period are of the utmost importance in the after-treatment of diabetes, when convalescence has been fairly established. I can point at least to one melancholy instance in which a return of the disease in a severe form was induced

by close attention to business in gloomy premises, and continued residence in an unhealthy atmosphere, nearly a year after every trace of sugar had been removed from the urine, and the health and strength of the patient completely restored.

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