ON THE USE AND ADMINISTRATION OF FAT.[1]

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SOME time ago, an attempt to swim across the Channel was made by Johnson, then the champion swimmer of England. At first he made good progress, but at length his strength seemed to fail, and when he was at last lifted into the boat by those who accompanied him, his limbs hung down utterly powerless. It appeared that this was not so much due to real muscular exhaustion, as to the effect of cold. We know that when a muscle is cooled down very much, the nerves which supply it refuse any longer to convey impulses to it from the nervous centres, so that however powerful the effort of the will may be, the muscles will no more respond to it than they would in an animal poisoned by curara. Prolonged exposure to the cold water of the Channel appeared to have induced this state in Johnson's muscles. Afterwards, when Captain Webb proposed to attempt the feat, I felt quite certain in my own mind that he would fail, not because I doubted his powers of endurance, but because I thought that his muscles must needs be affected by the cold in the same way as were those of Johnson. But, as the event showed, I was quite mistaken, for Captain Webb succeeded in his attempt. In coming to my conclusion, I had left out of account the influence which a thick coat of subcutaneous fat might have in protecting a human being from the action of external cold, just as it does the porpoise or whale, this coating being no doubt aided by the porpoise oil with which the skin of the swimmer was lubricated, and which still further prevented the loss of heat. One use of fat, in the economy, is to act as a protective against external cold. This protective power appears also to be useful to the individual by diminishing his chances of catching cold on exposure to draughts,

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and where the coating of fat under the skin is deficient or absent, we must supply its place by non-conducting articles of clothing. We rarely think of covering the chest of a fat person with chamois leather or thick flannel, but these coverings are both pleasant and useful for thin or emaciated persons. In cold climates, a coating of subcutaneous fat all over the body is a useful protection, but in warm weather, or in hot climates, it becomes exceedingly oppressive, as one may see by watching very stout persons or fat animals during the heat of summer. In some animals which are natives of tropical climates, or of regions in which the summer heat is great, although the cold during winter may be extreme, we find that fat, instead of being distributed over the body with more or less uniformity, is collected in huge masses at certain parts. In the zebu, or Brahmin bull of India, in the yak of Tartary, in the buffalo of the American prairies, and in the camel of the African or Asiatic deserts, we find large humps upon the back, which consist almost entirely of solid fat. On looking at a camel, we see that the hump is usually firm and solid, projecting stiffly from the back, but at times it may appear limp and loose, swaying helplessly from side to side, and doubling up like a half empty bag. On inquiring as to the reason of this, we are told that so long as a camel is well fed, the hump remains firm and solid, but that when the animal's food is insufficient it becomes thin, loose, and flabby, a great part of the fat being absorbed from it, while if the camel be kept absolutely without food for days, the protuberance will almost entirely disappear. When, on the other hand, food is again given, the hump regains its former dimensions, so that its use is apparently that of a reservoir of food, which may be drawn upon when the daily aliment is insufficient. We all know that the same thing takes place with regard to subcutaneous fat, as with the fat of the camel's hump, and that whenever the fat assimilated is insufficient for the wants of the economy, the person or animal becomes leaner and leaner, until the fat has almost entirely disappeared. To the question, Where has this fat gone? it is difficult to return a very definite answer. Probably some of it has undergone combustion, without being formed into any other tissue, but another part of it has probably gone to supply the waste of some more important organs, which thus are enabled to live, parasite-like, at the expense of the fat. The blood contains only about one-half per cent. of fat, the muscles more than 3 per cent., the

brain 8 per cent., and the nerves 22 per cent. Yet in spite of the large proportion of fat contained in the nerves, they are amongst the last organs to suffer under the process of starvation, and probably their waste is supplied by the fatty matters absorbed from subcutaneous cellular tissue, and brought to them by the blood. The different tissues probably require very different amounts of fat, and the high percentage of fatty matters contained in nervous substance indicates the necessity of fat for the proper performance of the functions of the nerves. Fat may be supplied to the body by various kinds of food—fatty, starchy, saccharine, and albuminous. For although these do not all contain fat, they are all capable of being converted into fat, to a greater or less extent, by the organism. It is not certain that the various fats formed from these different kinds of food have precisely the same composition. It is well known to feeders of cattle that fats differ in quality according to the food upon which the animal has been fattened, and that while, for example, the fat which horses lay on when fed upon corn is tolerably permanent, that produced by feeding on grass is soft, and quickly disappears when the animal is set to work. In his book on *Fat and Blood, and How to Make Them*, Dr. Weir Mitchell quotes the remark of an old nurse that "some fat is fast, and some is fickle, but cod-oil fat is easily squandered." One would suppose at first, that the fat taken in the food would be stored away in the adipose tissue without undergoing any change, but this does not seem to be the case. It appears rather that the fats are split up and modified in such a way during digestion and absorption, that, when deposited in the tissues, their composition becomes tolerably definite in each class of animal. Thus, the composition of the fat of a man will differ from the composition of the fat of a dog, although both may have been fed upon the same mutton suet, the composition of which differed from that of the fat of either. Subbotin found that when a dog was kept without food until all the fat had gone from the body, and was then fed with palm-oil containing palmitine and olein, but no stearin, it nevertheless laid on fat which contained stearin, although in somewhat less than half the normal quantity. When palmitine and stearin were given to a starving dog, but no olein, the fat it laid on contained even more than the normal quantity of olein though less stearin.

It would almost seem, then, that fat rapidly laid on, as in the case of these animals, contained a greater proportion of olein than

normal, whether this were present in the food or not. That fat may be formed from other kinds of food, such as starchy or saccharine, has been shown by Lawes and Gilbert, who found that in fattening pigs, four or five times as much fat was produced among the animals as was contained in their food, and by Liebig and others, who found that bees could form wax, which is a kind of fat, although they were fed on nothing but sugar. This is supported also by the fact that negroes grow fat during the time when sugar-canes are ripe, and when they are constantly sucking the saccharine juice. That fat may be formed from albuminous substances has been clearly shown by Voit and Bauer, in their researches on fatty degeneration, of which we will speak more particularly hereafter. Before the different kinds of food can become available for the wants of the tissues, they must be brought into such a condition as to pass through the walls of the intestine into the blood, and be carried about through the circulation. The starch is converted into soluble sugar by the ferments of the salivary glands and pancreas in the mouth and small intestine, although while it remains in the stomach this change is diminished or arrested by the acidity of the gastric juice. How the sugar yielded by the starch is converted into fat we do not precisely know, although it seems probable that the change of part of it at least into lactic or butyric acids may be one part of the process. The albuminous matters are converted into peptones by the stomach and pancreas. Some of these peptones are further split up during pancreatic digestion, so as to yield leucine, which belongs to the group of fatty bodies. The fats themselves are partially emulsionised, as well as partially saponified, by the pancreas. They then pass either through or between the epithelial cells, which cover the villi, into the lymph spaces in their interior, and thence through the lacteals, mesenteric glands, and thoracic duct into the general blood-current. The amount of fat in the blood may be very considerably increased by food. In a dog, which had fasted for four days, a diet of bread raised the proportion of fat in the blood from 2·6 in the thousand to 3·1; meat raised it to 3·8; and suet and starch to 4·1, a most important observation, to which we shall again have occasion to refer. All these foods, as we thus see, raise the proportion of fat; but besides the fat they all supply other substances to the blood which may be beneficial, but which, in excess, may prove more or less injurious. Thus bread supplies sugar as well as fat. If this

sugar undergo the proper changes in the body, it is useful, but if it be in such excess that its combustion is insufficient, it will produce thirst and the other symptoms which we meet with in glycosuria. If the appetite or digestion will not allow of the consumption of sufficient bread to produce this, we may have a deficiency of fat. Meat also, as we have seen, produces fat, but supplies also a large quantity of nitrogenous material which may, like the sugar, prove injurious when in excess. We usually suppose that a diet of meat is the best cure for failing strength, and for weakly persons we are accustomed to recommend beef-tea whenever they feel faint. But Ranke observed that an exclusively meat diet, instead of producing strength, caused weakness and muscular fatigue, the excess of waste nitrogenous products proceeding from the decomposition of this food in the organism seeming to act as a muscular poison.

In order, then, to keep the balance true, and supply the wants of the various tissues without having any excess of waste products, we must have an admixture of various kinds of food, and if one or other be deficient, we either throw additional work upon the organism by making it consume more than a fair share of another sort, and excrete the residue which it does not want, or the tissues and organs which most require the missing food will suffer in consequence. Now, the food which is more frequently deficient than any other is fat, and this may be either because the fat cannot be obtained, or because it cannot be digested. The late Dr. Hughes Bennett used to say that two of the main causes of tuberculosis were the dearness of butter and the abundance of pastrycooks. For fat is an expensive article of diet,—well-fed meat is dearer than badly-fed and lean meat. Butter is expensive, and amongst poor families its place is very often taken by molasses or jam, which no doubt gives a relish to the bread, and is enjoyed by the child, but does not supply the place of butter as a food. Hence, amongst the lower classes, both children and adults suffer because they are unable to obtain a sufficient proportion of fat in their food. The pastrycooks whom Dr. Bennett accused of causing tuberculosis amongst the upper classes, did it, he said, by disordering the digestion, of young girls especially, by puff-paste, and other things of that sort, and thus spoiling their appetite for food, and especially for the fat which they might obtain in abundance if they liked. The result is the same in both classes, for unless the fat be absorbed and assimilated, the result is the same as if the

patient could not obtain it. But we notice that in both upper and lower classes there are numbers of children who refuse fatty food, although their parents or guardians are sufficiently careful to prevent them from injuring their digestions by puff-paste, or anything of the kind. There are many children who will utterly refuse to eat a piece of fat meat. They will eat the lean, but carefully cut off every scrap of fat, and lay it at the side of the plate, and will submit to severe punishment rather than eat it. Some persons are in favour of punishing such children, and compelling them to eat fat, but such a course I regard as a total mistake. The instinct of the child is perfectly right, and its indications ought not to be disregarded. If the fat be swallowed under compulsion, it generally disagrees with the child, and makes it sick, as the poor thing well knows. In such cases the proper thing to do is to give the fat in another form. If any one of us were to swallow a lump of butter, by itself, it would very probably make us sick; but if we spread the same butter upon pieces of bread, we can take it not only without discomfort, but with enjoyment. Professor Hugo Kronecker once illustrated this to me very strikingly. He said: "Suppose you get a piece of butter, and are asked to make a sandwich, would you take the whole of the butter, spread it on one slice of bread, and then put the other unbuttered slice on the top of it? If you did, your sandwich would not be half so palatable as if you divided your butter, spread it upon both slices, and then put them together." The reason of this is simple, for in the latter case we get the fat in a much finer state of subdivision, and the more finely it is subdivided, the more do we enjoy it, and the more readily is it digested. A piece of solid butter swallowed alone would melt in the stomach, float about without undergoing digestion, and would probably begin to decompose and yield acrid fatty bodies, which would irritate the stomach and cause sickness. When finely divided by admixture with particles of bread, it would form a creamy mass, which would quickly pass into the duodenum, and be digested and absorbed. In the same way, these very pieces of fat which a child will cut from its meat and put aside, may be rendered quite palatable by being mixed with flour or potatoes. A piece of fat bacon, or the liquid fat in the plate, which would certainly make the child sick if swallowed alone, will be taken with great relish if chopped up finely and well mixed with a mashed potato. Whatever the fat may be which we wish a person

to swallow, we should endeavour, by every means in our power, to subdivide it minutely, if there be the least difficulty in digesting it. Besides this, we ought to seek to maintain this state of subdivision in the stomach. For although the fat may be finely subdivided at the time it is swallowed, yet during its sojourn in the stomach it may be melted by the warmth of the body, and the globules gradually agglomerating may again form a solid mass, which will have somewhat the same effect upon the stomach as if it had been swallowed in a solid mass at first. For this reason I think it is advisable, in administering cod-liver oil, to give it an hour or so after, instead of immediately after, a meal, because it will then have a shorter time to stay in the stomach, and will pass out quickly into the duodenum. I think it is better to give cod-liver oil in the form of an emulsion, with gum acacia, rather than with solution of potash or carbonate of potash, because the gum is little, if at all, affected by the gastric juice, whereas the potash will be neutralised, and its emulsifying properties destroyed, so that the particles of oil can again run together. This emulsion with gum acacia is borne by many persons who cannot take pure cod-liver oil, and with whom the potash emulsion also disagrees. Besides the differences in the digestibility of fat due to the mechanical condition of aggregation or subdivision, there are differences also which are due to their chemical composition. Thus, mutton fat is difficult of digestion, while pork fat is easily digested. Butter, too, can be readily taken, and is greatly enjoyed by some persons who cannot take other sorts of fat; and cod-liver oil is usually very well borne, and very easily assimilated. Many opinions have been advanced regarding this ready digestibility of cod-liver oil, and some have sought for its cause in the fact that this oil contains propylene in combination with fatty acids instead of glycerine, like most other fats. Others, again, have attributed it to the minute quantities of iodine, and others to the biliary matters which are found in the oil. The last seems by far the most reasonable supposition. For it has been shown by Neumann that oil of any sort will pass much more readily through a filter, or through an animal membrane moistened with bile, than through one moistened with water. This is still further borne out by the fact which the late Dr. Hughes Bennett used to mention in his lectures, and which has recently been confirmed by the observations of my friend Dr. Russell, that the coarser kinds of cod-liver oil, though more disgusting to the taste, are sometimes more easily

digested than the so-called better qualities. These coarse oils are obtained from livers which have been longer exposed to heat, and contain more of the biliary substances. But it is not improbable that the peculiarity in the chemical composition of the oil which I just now mentioned, may have also something to do with its digestibility and utility. The remark of the old nurse quoted by Weir Mitchell, that cod-liver oil fat was soon squandered, seems to point to the greater mobility, if we may so term it, of the cod-liver oil than of other fats, so that it is both more readily laid on and more readily reabsorbed from the tissues than other fats. Perhaps it is to this greater mobility that the beneficial effects of cod-liver oil, as compared with those obtained from the use of other fats, such as butter, are to be ascribed. In a former part of this paper I observed that the quantity of fat circulating in the blood could be greatly increased by food. Now it may not matter very much to tissues of tolerable permanency, such as the sub-cutaneous fat, what the fatty substances in the blood may be, as time is allowed for these substances to undergo any necessary modifications before they become deposited in the permanent adipose cells. But the case may be different with mobile tissues, such as the colourless blood corpuscles, which are going to form pus, or with the rapidly developing young cells which help to compose the muco-purulent expectoration in bronchitis. For these it may be a matter of great importance that the fat should be easy of assimilation, the time allowed for such assimilation before the cells are thrown off being very limited.

Some time ago I went to a lecture on sick-room cookery. The lecturer described and demonstrated the different methods of preparing gruel, and observed that whenever the gruel was required for a case of bronchitis, a piece of butter should always be added to it, "because," said she, rubbing her chest with her hand, "butter is so very healing to the inside." She was evidently under the impression that the piece of butter got into the chest, ran all about, and thoroughly greased the air-passages. Her notions of physiology were very confused, but I think her practical observation was perfectly correct. It appears to me that in bronchitis, both acute and chronic, a little cod-liver oil is generally much more serviceable than cough mixtures, and patients express themselves very grateful for the relief which it affords by lessening the cough. Indeed, in many cases of chronic bronchitis, it seems to me to be almost the only remedy which affords any marked relief. The use of this

oil in phthisis is now so universal that I need say nothing about it, but I will pass on to consider the use of fats as a nervous food. I have read that a well-known barrister always swallowed a large dose of cod-liver oil before going to plead a case, because it enabled him to do better mental work than anything else he could take. I myself, after a trial of various things, have come to the conclusion that fat bacon is one of the most satisfactory things upon which to do hard mental work, and I invariably take it for breakfast whenever I have first to see a number of patients and afterwards to deliver a lecture. We have already seen that the nervous system contains a very large proportion of fat, and we can well imagine that if fat be deficient from the food, that system must necessarily suffer; and more especially is this likely to be the case if, in addition to the deficiency of fat, we have an excess of the products of nitrogenous waste, such as we get from an almost exclusively animal diet. A distinguished physician has made the observation that the prevalence of Bantingism has thrown a great number of nervous cases into the doctor's hands, and a friend lately narrated to me the case of a relative of his own who used to suffer from undefined nervous symptoms. Sometimes he sat and moped about all day, simply because he felt that he could not go out alone, and that he was unable to do anything. He would sometimes start for a walk, and after proceeding a short distance, would turn back again. He lived to a great extent on animal food, and, notwithstanding this disinclination to go out alone, he took a great deal of exercise, both hunting and shooting, so that his symptoms were neither due to want of food nor lack of exercise. Some time afterwards he went to Ireland, and whilst there lived on very fat meat and whisky. All the time he did this he felt perfectly well, but whenever he came back and resumed his animal diet, the symptoms returned.

In persons of a gouty temperament, living to a great extent on animal food, especially when they reach middle age, we not unfrequently observe sugar in the urine. It is, I think, a mistake to term this diabetes; it should rather be called gouty glycosuria. The cause of it appears to be that the oxidation in the body is insufficient to consume all the substances taken in as food, and one or other of them must needs undergo imperfect combustion. Accordingly we find that it is sometimes the nitrogenous products of waste which pass out in a state of imperfect oxidation, large quantities of uric acid and urates appearing in the urine instead of

urea. At other times it is the non-nitrogenous products, such as sugar and fat, which escape oxidation, the uric acid being absent from the urine whilst sugar appears, or both uric acid and sugar may be wanting, and fat is accumulated. These processes of imperfect oxidation seem to be very closely connected indeed, for Seegen has noticed, in his work on diabetes, that the disease is often preceded or accompanied by an immense accumulation of fat, so that one patient, who went to be under his treatment at Carlsbad, had actually to be conveyed in a luggage van instead of an ordinary railway carriage. We also notice very frequently that the gouty glycosuria of middle age occurs in stout persons. The same deficiency in oxidation which leads to the accumulation of fat in the subcutaneous cellular tissues, or about the viscera, may also lead to fatty degeneration of organs. The pathology of fatty degeneration has been exceedingly carefully worked out by Voit and Bauer, and the method they adopted was to study the changes which took place in animals during phosphorous poisoning. It is well known that after poisoning by phosphorus the organs of animals are found to be in a state of intense fatty degeneration, and the question which Voit and Bauer tried to solve was, "Whence did this fat come?" It might, they said, have come from the food, or it might have been absorbed from the subcutaneous cellular tissue and deposited, for example, in the liver, or it might have been formed in the liver and other organs from the albuminous constituents of these organs themselves. They solved the question in the following way:—they starved a dog until all its fat had completely disappeared, and then poisoned it with phosphorus. At its death its organs were found to be in a state of exquisite fatty degeneration. The fat here could not have come from the food, for the animal got none; it could not have been absorbed from the subcutaneous cellular tissue and deposited in the liver, for all the subcutaneous fat had gone before the phosphorus was administered. It must therefore have been formed *in situ*, from the albuminous constituents of the organs themselves. So much being ascertained, they had next to discover whether the fat was due to increased tissue change, or diminished oxidation. The albuminous constituents of the organs, they considered, were split up into some nitrogenous substance, and into fat. Normally, both of these undergo oxidation, the nitrogenous substances into urea, and the fat into carbonic acid and water, the splitting up of the tissue and the oxidation going on nearly *pari passu*. If the tissues

split up too rapidly for the products of their decomposition to be oxidised, it is obvious that we shall either have the fat accumulating, or the nitrogenous products imperfectly oxidised, as, for instance, in the case of fever, or of gouty glycosuria. If the amount of oxygen received by the tissues be diminished below the normal, a similar result will occur. In phosphorous poisoning both of these were observed, for the urea was greatly increased, showing that the nitrogenous tissues were split up more rapidly than usual, while the amount of carbonic acid exhaled was diminished, showing that the combustion going on in the body was less than usual. The combustion of the tissues is kept up by the oxygen carried to them from the lungs by the red blood-corpuscles, and whenever the supply of oxygen to the tissues is diminished, either by impoverishing the blood of these corpuscles, or by lessening the flow of blood through the part, accumulation of fat or fatty degeneration is likely to ensue. This fatty accumulation from insufficient oxidation may sometimes be observed in women after severe flooding, the patient becoming exceedingly anæmic, and at the same time very fat. The fatty degeneration due to insufficient oxidation is seen in the muscles of a paralysed limb, where want of exercise has nearly stopped the flow of blood, or in the heart, where the coronary arteries have been rendered too small for the normal heart by calcareous degeneration, or where the hypertrophied heart has grown too big for these arteries to supply it. This fatty degeneration of the heart is frequently met with in persons of a gouty habit, tending to become fat, and at the same time suffering from bronchitis, sometimes complicated by emphysema. In treating such persons the question arises, "Does a fatty condition of the heart, and the tendency to accumulate fat under the skin contraindicate the use of the cod-liver oil which might be beneficial to the bronchitis?" For my own part I am inclined to say no. It is quite true that the oil, after being absorbed, will very probably undergo oxidation more readily than the fat which has been forming in the tissues, but it may be nevertheless beneficial by supplying the wants, not merely of the young cells in the bronchial tubes, which form the expectoration, but by supplying the wants of the nervous centres. In such cases I sometimes give cod-liver oil, notwithstanding the fatty condition of the heart, and trust to increase the oxidation by administering iron so as to increase the number of the red-blood corpuscles, at the same time trying to

eliminate some of the waste materials by keeping the bowels freely open.

If I were to pursue this subject into all its ramifications, I should take up more time than could be allotted to several papers such as this; and therefore in the present one I have merely attempted a slight sketch of some of the more prominent uses of fat, and tried to give a few hints derived from physiological observation, and confirmed, I feel certain, by the experience of many medical men regarding the method of administering fats, and the diseases in which fat is chiefly serviceable.