THE LUMLEIAN LECTURES

ON

THE DIGESTIVE FERMENTS, AND THE
PREPARATION AND USE OF ARTIFICIALLY DIGESTED FOOD.*Delivered before the Royal College of Physicians.*By WILLIAM ROBERTS, M.D., F.R.C.P., F.R.S.,
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LECTURE III.*

NUTRITIVE VALUE OF PEPTONISED FOOD.

At the outset of this inquiry we are met with the question, Is it certain that the ultimate products of digestion are of equal nutritive value to the mixed transitional products which are produced in succession, and probably absorbed as the food is gradually transformed in the alimentary canal?—in other words, are maltose and peptones alone as valuable to the economy as a mixture of these substances with the several dextrines and hemipeptones which are presented to the absorbent surfaces in the course of natural digestion?

With regard to the products of starch-digestion, no direct experiments have been made on the nutritive value of maltose, and we can do little more than conjecture that the intermediate dextrines have an usefulness of their own. That they are absorbed seems proved (as might have been expected from their known diffusibility), for they have been detected in the blood, and especially in the blood of the portal vein.

With regard to peptones, we have more information. It was naturally assumed by the earlier observers, who identified peptone as the chief ultimate product of digestion, that this was the form under which proteids were taken up by the absorbents and introduced into the blood for the nutrition of the tissues. But, ten years ago, doubts were cast on this conclusion. It was alleged by Brücke and Voit that the nutrition of the tissues was maintained, not by peptone, which was unfitted for this purpose, but by soluble albumen, which was absorbed in the undigested state from the primæ viæ; and that the office of peptone was a subordinate one, resembling that of gelatin, and consisted in aiding to preserve the tissue-albumen from too rapid destruction. Direct observations on the nutritive value of peptones have, however, shown this paradoxical view to be untenable. As the point is one of importance, I will endeavour to lay before you the proofs which have been already adduced of the food value of peptones, and I will supplement these by some observations by myself.

P. Plosz (*Pflüger's Archiv für die ges. Physiologie*, 1874, p. 323) was the first to put this question to the test of direct experiment. He fed a puppy dog weighing 1,302 grammes with an artificial compound made of fat and sugar, in imitation of milk, but in which the casein was replaced by artificially digested fibrin. In the course of eighteen days of this diet, the dog grew and increased 501 grammes in weight.

R. Maly (*Ibid.*, p. 585) performed a similar experiment on a pigeon. He first fed the pigeon for several days on a regulated quantity of wheat, until he had ascertained the quantity requisite to keep the bird in a state of nutritive equilibrium, in which it neither gained nor lost weight. He then made an artificial corn from starch, fat, gum, salts, and water, but in which the gluten was replaced by fibrin-peptone, and fed the pigeon on the same quantity of this artificial corn as he had before given of the natural corn. Under this novel diet, the bird, after a short apprenticeship, not only maintained its weight, but actually put on flesh. This experiment seemed to show that peptone was even superior to natural gluten as a nutriment.

It was, however, objected to these experiments that they did not rigorously prove that peptone could build up the tissues, inasmuch as the increase of weight might have been due to an excessive accumulation of fat or of water, and that there might have been not an increase, but a decrease of the structural elements which contained nitrogen.

To meet these objections, Plosz and Györgyai (*Pflüger's Archiv*, Band x, 1875, p. 536) instituted a third set of experiments on a dog

weighing 2,753 grammes. He was first brought down by a diet of simple water to a weight of 2,531 grammes. He was then fed on a mixture composed of sugar, starch, and fat, and containing, in addition, five per cent. of purified peptone. Of this mixture, about 400 grammes were daily administered to the animal for a period of six days. In these six days, the dog took in with his food 14.45 grammes of nitrogen; but the total of the nitrogen excreted by the urine and feces only amounted to 13.46 grammes, so that nearly one gram of nitrogen had been retained in the body of the animal, which had increased in weight 259 grammes. This experiment went to prove that peptone served to repair the wear and tear of the nitrogenised structural elements, and even contributed something to the increase of weight.

Adamkiewicz (*Natur und Nahrwerth des Peptons*, Berlin, 1877), by a still more rigorous method, in a laborious series of experiments on a dog which was fed on a diet wherein the only possible source of nitrogen was peptone prepared from blood-fibrin, arrived at the conclusion that peptone supplied nitrogen to the solid tissues, and that it possessed a nutritive value equal to albumen, or even slightly superior; and that, therefore, it could not be looked on as a by-product of digestion, but as the chief resultant of the transformation of proteids in the alimentary canal.

The experiments above cited seem sufficient to settle definitely the question raised by Brücke and Voit, and to establish the nutritive value of peptone as a source of nitrogen to the tissues. It seemed, however, desirable to obtain direct proof of the nutritive value of peptonised milk, as compared with the natural article. My observations led me to the conclusion that it was far easier to get a supply of peptonised aliment suitable for invalids by the artificial digestion of milk by pancreatic extract, than by any other method; but, in so important a matter as the feeding of invalids, inference and conjecture seemed hardly a sufficient basis for actual practice.

The questions I proposed to myself were: 1. Is artificially digested or peptonised milk alone sufficient to sustain nutrition? and 2. Is it as efficient in this respect as natural milk? For the purpose of answering these questions, I procured four kittens, of the same brood, eight weeks old. Kittens at this age thrive perfectly on an exclusively milk diet. Two of the kittens were fed on natural milk, and the two others on milk previously digested by pancreatic extract. The digestion of the milk in the latter case was carried out to full completion—that is to say, until the milk became greyish and bitter, and no longer gave any precipitate with acetic acid, nor even with nitric acid. The animals were permitted to have as much of their respective foods as they could consume. The experiment was continued for a period of twenty days. The quantity consumed by each pair was as nearly as possible the same. All four continued in perfect health, and took their nutriment greedily. I was surprised to find that the pair fed on peptonised milk showed no repugnance to the bitter taste of their food, but appeared to relish it quite as well as their companions did their natural milk. The following table exhibits the gain in weight at the end of twenty days by each of the four kittens. The weights are given in grammes, and in round numbers.

Diet.	Initial Weight.	Weight at the end of 20 days.	Increase of Weight.	Increase of Weight per Cent.
Natural milk	No. 1—338	514	176	52
	" 2—558	838	280	50
Fully peptonised milk	" 3—403	626	223	55
	" 4—374	562	188	50

The table shows that the percentage increase of weight was very nearly alike in all four animals. No difference could be perceived in the sleekness of their coats, nor in the vivacity of their gambols. The experiment proves that peptonising the milk in no degree spoils its nutritive value. It also shows, as might have been expected, that in healthy animals, with abundance of digestive power, there is no advantage to be gained from the administration of food in a predigested state. The quantity of food which is taken and absorbed appears to be regulated not so much by the quantity which can be digested as by the quantity which can be assimilated. This experiment had an interesting sequel. After Nos. 3 and 4 had been fed on fully peptonised milk for a period of twenty days, they were fed for a period of ten days on partially peptonised milk. By using a less quantity of the pancreatic extract in proportion to the milk, and by allowing the process of artificial digestion to go on for not more than half the time allowed in the previous experiment, only a partial conversion of the casein was effected. As nearly as I could judge by the precipitate caused with acetic acid, the casein was digested to about the extent of one-half. In these circumstances, I certainly expected that Nos. 3 and 4 would gain weight as before, and would continue to thrive as well as

* Concluded from page 649 of last number.

Nos. 1 and 2. It might have been anticipated that, in these new conditions, the proper digestive powers of Nos. 3 and 4 would come into play and complete with ease the unfinished work of the artificial process; but events did not pass exactly as I anticipated. The annexed table shows the actual results. The weights, as before, are given in *grammes*.

Diet.	Initial Weight.	Weight on 3rd Day.	Weight on 5th Day.	Weight on 7th Day.	Weight on 10th Day.
Natural milk	No. 15—514	551—gain 37	570—gain 19	593—gain 23	618—gain 25
Half-peptonised milk	" 2—838	900—" 62	935—" 36	993—" 57	1063—" 70
	" 3—626	693—" 67	687—loss 6	681—loss 6	693—" 12
	" 4—562	645—" 83	638—" 7	648—gain 10	683—" 35

No interval was allowed to elapse between the two sets of experiments, so that the initial weights in the second set were the same as the terminal weights in the first set. The abrupt alteration in the diet of Nos. 3 and 4 produced a marked disturbance in their nutrition; but there was no declension in their general wellbeing, and they continued to take their modified diet with the same avidity as before. In the first three days, Nos. 3 and 4 showed an unusual increase of weight—an increase quite out of proportion to that of their companions. Then came a check; in the next four days, they not only showed no gain, but showed even a slight loss of weight. In the last three days, they began to gain weight again, and were evidently recovering from the temporary check caused by their change of diet. The explanation of this series of events which has presented itself to my mind is the following; but I by no means wish to lay stress on its accuracy. It seemed as if the enforced rest imposed on the digestive organs for a period of twenty days, during the use of fully predigested food, had temporarily diminished their natural vigour, just in the same way as the disuse of a limb diminishes for a time the strength of its muscles. During this first period, immediately following the change of diet, the unemployed digestive powers were suddenly called upon to resume their wonted activity; but, owing to their enfeeblement from disuse, they were unable to respond to the call with due promptness, and undigested materials accumulated in the intestine. This accumulation accounted for the unusual increase in weight during the first period. During the next period, the digestive embarrassment made itself felt, and gave a check to the processes of growth and nutrition, and the animals ceased to grow and gain weight. During the last period, the temporary enfeeblement of the digestive organs was passing away, in proportion as renewed exercise was restoring them to their original vigour, and growth and increase of weight again commenced.

Whether this explanation be trustworthy or not, the lesson indicated by it is probably a true one; namely, that, except in extreme cases, when the digestive power is wholly lost or in complete abeyance, it is more advantageous to use a food which has been subjected to partial artificial digestion than a food in which the process has been carried out to completion. If the patient possess any digestive power at all, it is better that that power should be kept in exercise, than that it should be permitted to deteriorate still further from total disuse. This is in agreement with the rule we apply in other cases of enfeebled function, according to which we endeavour to combine partial rest with moderate exercise.

Clinical Experience of Peptonised Food.—The extreme difficulty of arriving at reliable conclusions in regard to the effect of therapeutical agents is well known to every sober-minded inquirer. The difficulty is not less, but probably greater, in judging of the effects of dietetic means. I have now had a considerable experience, extending over a period of two years, of the use by invalids of peptonised milk and peptonised milk-gruel; and it would be an easy task for me to recite a string of cases in which improvement and recovery followed the use of these articles of diet. But evidence of this sort would be wholly delusive unless checked by such an analysis of the circumstances of each case as would enable me to isolate the influence of the dietetic means. In the immense majority of cases, such an analysis would be obviously impossible; the conditions to be taken into account would be too numerous, and their relative influence too difficult to determine. In a question of this kind, one is obliged in a large degree to fall back on general impressions, and on deductions based on physiological considerations. Nevertheless, there are certain cases—most of them cases of incurable disease—in which the conditions are sufficiently simple to permit direct trustworthy conclusions to be drawn.

I found that peptonised milk-gruel was generally preferred, as being more agreeable to the palate, to simple peptonised milk; and by far the larger number of my observations were made with the former preparation. I was also soon satisfied that, with most rare exceptions,

peptonised milk-gruel was perfectly acceptable to the invalid's stomach; and that a diet composed exclusively of this article could be used for many consecutive weeks without the slightest sign of failure of nutrition.

The cases in which the use of peptonised aliment appeared to produce the most striking benefits were those in which complete anorexia prevailed, and those in which the stomach was intolerant of food and immediately rejected every form of nutriment. A brief review of the results obtained in cases of this kind will, I think, prove instructive.

Uremic Vomiting.—In advanced Bright's disease, incessant vomiting is sometimes a distressing and intractable symptom. In some cases of this class, I have seen the vomiting at once and permanently allayed by the use of peptonised milk-gruel. The downward course of the disease may not have been a moment checked; but the relief to the dying patient was great.

Gastric Catarrh.—That form of gastric catarrh which is the Nemesis of alcoholic excess often yields immediately to the use of peptonised food. In the later periods of cirrhosis, there frequently prevails severe intolerance of every kind of food—the stomach rejecting even beef-tea and diluted milk in the smallest quantities. The relief afforded by the use of peptonised milk-gruel in some of these cases is most striking; the vomiting ceases almost from the first, and the intolerable sense of distension diminishes.

Crises of Cardiac Disease.—Persons suffering from cardiac dilatation and valvular incompetency usually encounter one or more crises which are susceptible of relief, before finally succumbing to their disorder. These crises are marked by a general venous stagnation, with severe congestion of the lungs, liver, and kidneys, and rapidly rising dropsy. Associated with these symptoms, there is generally almost complete inability to take food, and sleeplessness. In this condition, I have seen marked relief follow the use of peptonised aliment. I have long observed, as I doubt not have many of you, that the condition here described is often alleviated in the most striking manner by the use of exclusively liquid nourishment—such as milk or milk-gruel, given in small portions subcontinuously, or sipping, as it were, throughout the waking hours; the patient being never permitted to take a distinct meal, nor a particle of solid food. As my practice has been to direct, in cases of this class, the administration of the peptonised aliment in this sipping fashion, the gratifying results noted have been partly due to the mode of administration; but I have been convinced by more than one example, when the same liquid nourishment in the natural and in the predigested condition has been used in succession, that there was a distinct superiority in the predigested article.

Pernicious Anæmia.—In the earlier periods of this singular disorder, I am inclined to hope that predigested aliment may prove a valuable resource. In cases where the ailment, although fully declared, was still of comparatively recent origin, I have in the last eighteen months seen the disorder checked under the use of peptonised milk-gruel. In one case, owing to the irritability of the stomach, the milk-gruel was at first administered *per rectum* with pancreatic extract, but was afterwards tolerated by the stomach. In three of these cases, the amelioration went on to complete restoration. In cases of longer standing, I have failed by the same means to obtain the slightest improvement.

Gastric Ulcer.—The use of an exclusively liquid nourishment, given subcontinuously in the manner before indicated, is a well-known and most efficacious mode of treatment in these cases; but, since adopting the plan of giving peptonised milk-gruel, I think I have perceived that the results were distinctly better than before, especially in cases associated with epigastric pain. The almost absolute rest procured by this food for the ailing organ appeared to be an additional advantage. I may be permitted to mention one case. The patient had suffered from copious and repeated hæmatemesis, and from severe epigastric pain. The irritability of the stomach was such that the simplest nourishment, given in the smallest quantities, was immediately rejected. Peptonised milk-gruel was, however, tolerated at once; vomiting only occurred two or three times during the first two days of the treatment, and then ceased, as did likewise the epigastric pain. This patient used no other food for a period of six weeks, and took daily from two to three quarts, with steady recovery of flesh and strength.

Pyloric and Intestinal Obstruction.—Peptonised aliment would appear to be especially suitable for use in these cases; but, so far, I have been somewhat disappointed in the results. The vomiting has generally been effectually controlled; but I have not been able to convince myself, in cases of pyloric stricture, that the fatal event was delayed even a single day. When the obstruction has been temporary, and due to a removable cause, the results have been, of course, more satisfactory.

I should be glad to see a further trial made of peptonised, or partially peptonised, milk in the gastric and intestinal catarrh of infants. In one severe case of this class, a favourable result was immediately

obtained; in another case, there was greater tolerance of food, and more comfort after it, than with the use of simply diluted milk. It would be interesting, also, to have experience of the use of peptonised aliment in typhoid fever and in old age. The greater variety which can now be given to this form of food by the preparation of peptonised soups, jellies, and blanc-manges, will obviate the monotony sometimes complained of under the continuous use of peptonised milk-gruel.

THE USE OF PANCREATIC EXTRACT AS AN ADDITION TO FOOD SHORTLY BEFORE IT IS EATEN.

The administration of pancreatic extract with or immediately after a meal can, I think, have only a limited utility. On entering the stomach, the pancreatic ferments encounter the acid of the gastric juice; and, when this rises above a certain point, the activity of the ferments is destroyed. Still a not inconsiderable interval of time must elapse before this point is reached; and during this interval the pancreatic ferments can accomplish a certain amount of work. I have repeatedly administered pancreatic extract in this way; but I am unable to say positively that I have seen benefit from this mode of administration. There is, however, a modification of this plan, which I have lately put in practice, that promises better results. It is to add the extract to the food fifteen or twenty minutes before it is eaten. Certain dishes commonly used by invalids—farinaceous gruels, milk, bread-and-milk, milk flavoured with tea or coffee or cocoa, and soups strengthened with farinaceous matters or with milk—are suitable for this mode of treatment. A teaspoonful or two of the liquor pancreaticus should be stirred up with the warm food as soon as it comes to table. And such is the activity of the preparation that, even as the invalid is engaged in eating—if he eat leisurely, as an invalid should do—a change comes over the contents of the cup or basin; the gruel becomes thinner; the milk alters a shade in colour, or perhaps curdles softly; and the pieces of bread soften. The transformation thus begun goes on for a time in the stomach; and one may believe that, before the gastric acid puts a stop to the process, the work of digestion is already far advanced.

This mode of administering pancreatic preparations is simple and convenient. No addition of alkali is required, and of course no final boiling. The only precaution to be observed is that the temperature of the food, when the extract is added, should not exceed 150° F. (65° C.). This point is very easily ascertained; for no liquid can be tolerated in the mouth, even when taken in sips, which has a temperature above 140° F. (60° C.). If, therefore, the food is sufficiently cool to be borne in the mouth, the extract may be added to it without any risk of injuring the activity of the ferments.

Pancreatic Extract as an Addition to Nutritive Enemata.—Pancreatic extract is peculiarly adapted for administration with nutritive enemata. The enema may be prepared in the usual way with milk-gruel and beef-tea; and a dessert-spoonful of liquor pancreaticus should be added to it just before administration. In the warm temperature of the bowel, the ferments find a favourable medium for their action on the nutritive materials with which they are mixed; and there is no acid secretion to interfere with the completion of the digestive process.

I have now had some experience in this method of alimentation, and have been satisfied with its success. In one case, a patient suffering from postpharyngeal abscess which entirely occluded the œsophagus, was nourished exclusively for a period of three weeks (until the abscess broke) on enemata or milk-gruel mixed with pancreatic extract.

OCCLUSION OF THE LARYNX: INTERNAL LARYNGOTOMY.—Professor K. Störk relates, in the *Wiener Medizinische Wochenschrift* (No. 46, 1879), the case of a boy aged 7, who three years previously had diphtheria, for which tracheotomy had been performed, and he had since worn an unfenestrated cannula. Some time after the operation, he was brought to Dr. Störk in consequence of having become dumb. Laryngoscopic examination showed a normal condition of the parts as far as the interior of the larynx; beyond the vocal cords, a *cui-de-sac* was noticed. The vocal cords moved, but without sound; there was a remarkable absence of secretion. Dr. Störk diagnosed complete adhesion of the cricoid cartilage. On examination with a small tracheal speculum, a wall of mucous membrane was found to have been formed between the larynx and trachea, arching over the latter like a dome. Dr. Störk consequently resolved to perform internal laryngotomy. For this purpose, he used a knife one-fifth of an inch long, set at a right angle to the hand, with which he carefully divided the adherent parts from below upwards and from behind forwards; this having been done, a specially constructed dilating apparatus was applied. There was little hæmorrhage during the operation; and the only difficulty arose from the narcosis. After the operation, the laryngeal opening having been dilated and the tracheal opening closed, the patient was able to speak.

THE CROONIAN LECTURES ON SOME POINTS IN THE PATHOLOGY AND TREATMENT OF TYPHOID FEVER.

Delivered before the Royal College of Physicians of London.

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LECTURE III.*

WE may divide the symptoms of typhoid fever into two classes: first, those due to the general febrile state; secondly, those depending on the local lesions. With regard to the former, we may distinguish those cases where the treatment has been applied from the first, and the fever prevented, as it were, from getting the upper hand, and those where it has not been resorted to till all the symptoms of the typhoid state have been allowed to become fully developed. In order to show the effect which we not unfrequently obtain, even in the latter class, I will briefly narrate a case which has recently been under my care.

Arthur C., aged 22, was admitted into the Middlesex Hospital on the afternoon of November 17th, the twenty-first day of his illness. On October 26th, he had been attacked by rigors, followed by the usual symptoms of fever; and on the 29th, he took to his bed. On the following day, diarrhoea appeared. On November 2nd, he became delirious, and had so continued more or less till his admission. The case then seems to have been a very severe one from the first. The onset was sudden; the patient took to his bed on the fourth day, and became delirious on the eighth.

On admission, he was very prostrate, and in a state of stupor, from which, however, he could be roused by loud speaking. Pulse 144; temperature 104.6°. My clinical assistant ordered him to be sponged with cold water; and at 6 P.M., the temperature being still 104°, gave him twenty grains of salicylate of soda. The temperature fell to 102.2°; but at midnight was again 104°. He now administered thirty grains of quinine; this caused vomiting, which continued during the night. (I may say I never give these remedies, under such circumstances, where there is much stupor; far better results are obtained by bathing, with less risk of causing unpleasant symptoms.)

When I saw him at ten the next morning, he was in a state of profound stupor, from which he could not be roused; his face was livid and dusky, pupils dilated, muscles tremulous; pulse so small and irregular that it could not be accurately counted, but was about 160; respirations 36; temperature 103°. There were fine crepitant *râles* audible all over the chest, extending to the apices.

I ordered him a pint of champagne and eight ounces of brandy daily, and a mixture of hydrocyanic acid and soda to check the vomiting (which it did not do), and directed him at once to be put into a bath at 65°. He remained in it for fifteen minutes, and when taken out was shivering violently. This I regarded as a favourable sign, as it indicated that the nervous system retained its powers of reaction. At mid-day, he was still shivering; and though still in a state of stupor, his general appearance had improved. At 2.15, the temperature having risen to 104°, the bath was repeated at 70° for ten minutes, and again at 4 P.M.; but this last had so little effect that another was given an hour later. At 7 P.M., a fifth bath was given; and at 11 P.M., a sixth. This frequent repetition was necessitated by the rapid rise of temperature and the recurrence of the alarming coma. During the day, he vomited everything he took. Feeding by the mouth had to be desisted from, and an enema of beef-tea, brandy, and opium, was administered every three hours.

At 3 A.M. on the 19th, a seventh bath was given; and at 6 A.M., an eighth. When I saw him in the afternoon, his condition was manifestly improved; the stupor had passed off; he put out his tongue when told, and tried to speak; the vomiting had ceased. Pulse was now 132, of better quality; temperature 101.6°. From this time, a slow but steady improvement manifested itself, but the temperature continued to rise a few hours after each bath, and they had to be repeated at gradually increasing intervals. Thus, during the first twenty-four hours, eight baths were given; during the second twenty-four hours, also eight; during the

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