Kant in his *Physical Researches*, we may at last find ourselves face to face with speculations which can be properly dealt with only by men of profound—say of the profoundest—mathematical and physical knowledge: men competent to deal, for example, with Sir William Thomson's theory of vortex-atoms, the interest of which is already so widely recognised. Whatever be the ultimate conclusion, we must not allow our road to it to be encumbered by *à priori* arguments about the infinite divisibility of matter. The extent to which the physical division of a given quantity of matter can be carried is a question for the physicist, and for him alone. Questions about the infinite divisibility of the space which matter occupies we may safely leave to the proper authority—the geometers.

There is, indeed, no *à priori* road to physical truth. We must never forget the maxim, which cannot be better expressed than in the words of Professor Tait, that advances in physical science come or not according as we remember or forget that our science is to be based entirely upon experiment, or mathematical deductions from experiment. It is by an enormously extended series of experiments, and not by arguments merely speculative, that we gain the assurance that no portion of matter, however small, goes out of existence or comes into existence in any chemical or physical operation whatever. If we neglect the maxim, we may construct systems; but they will not be systems of philosophy in any true sense of the phrase. And, apparently, so-called philosophical generalisations may be too hastily made; for, according to Professor Tait, even the purely space-relation, or geometrical conception of position, need not necessarily be relative, provided that something like the idea of Riemann, Helmholtz, and others, have an actual existence in the universe.

I conclude by saying that, if we would avoid verbal disputes, we should always keep before us what is meant by physical necessity. When it is said that such and such a physical consequent necessarily follows such and such a physical antecedent, all that is meant (at all events, ought to be meant) is that the given consequent will follow the given antecedent, so long as the physical laws we recognise remain unchanged. Practically speaking, physical necessity amounts to much the same thing as necessity proper; for the belief in the uniformity of nature and of natural sequences may be supposed to exist in the minds of those to whom arguments from physical necessity are addressed. If a proposition bear the stamp of physical necessity, another proposition which conflicts with it may justly enough be deemed incredible, or in a sense impossible; that is to say, physically impossible. But to class such conflicting proposition with those which are universally regarded as self-contradictory, or to say that its truth is inconceivable, unthinkable, and so on, or impossible in the sense of unconditionally impossible, is to assert that which may be contradicted, and actually is contradicted, by the mere play of the imagination, and by the constructive art of the mechanician and the painter and the sculptor.

NEWCASTLE-ON-TYNE.—Mr. Armstrong's reports abound in valuable tables and diagrams, which add much to their interest and completeness. His last report contains, in addition, a startling exemplification of domestic dangers from poisoning, in the shape of a flaring sample of wall-paper, which contains arsenic to the extent of 0.73 per square foot. The paper in question is one of a new and favourite pattern, consisting of dull-green fruit and leaves, pink apple-blossoms, greyish-green grasses, brown birds with yellow markings, and blue butterflies with brown and yellow markings, on a blueish-grey ground. The surface of the paper is dull, and the colouring-matter separates on slight friction. The adornment of the bedrooms of a house with this gorgeous paper led to five of the members of the family showing signs of arsenical poisoning. During the year 1878, 5,484 births and 3,423 deaths were registered in the borough, representing rates of 38.8 and 23.7 per 1,000 respectively. The birth-rate shows a decrease of 0.6 and the death-rate an increase of 1.4 per 1,000, as compared with the rates for 1877. The zymotic rate was 4.4 per 1,000, against 2.4 for each of the two preceding years. The chief epidemic of the year was one of scarlatina, which was fatal in 219 instances. Typhus caused 9 deaths, enteric fever 52, whooping-cough 87, and diarrhoea 218 deaths. Bronchitis and pneumonia caused 385 deaths, as compared with 443 in 1877. The number of infantile deaths was 888, or 16.2 per cent. of the registered births. The non-certified deaths numbered 119. A total of 467 cases of infectious disease were made known to Mr. Armstrong during the year, and were duly attended to. Sixty-five patients (13 suffering from typhus, 26 from enteric fever, 14 from scarlet fever, and 12 from other diseases) were admitted into the Fever Hospital, which, unventilated, dilapidated, and defective as it is, yet proved of the greatest service. Mr. Armstrong's personal action seems to be very energetic; and it would be well if, in this respect, he were followed more closely by his sanitary authority.

OBSERVATIONS

ON

THE DIGESTIVE FERMENTS, AND THEIR THERAPEUTICAL USES.*

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II.

PEPTONES AS FOOD.—Although we have been able for many years to imitate digestion very accurately in the laboratory, the proposal or suggestion to feed patients with artificially digested food has hardly yet passed beyond the tentative stage. There cannot be a doubt that, if we had at our disposal an available supply of artificially digested (or peptonised) proteids in a state fit for human food, we should find numerous conditions in which such a resource would offer promise of important advantage. In the alimentation of fevers, in the malnutrition of infants, in various gastric and intestinal lesions; in short, wherever natural digestion was partly or wholly in abeyance, we should find an ample field for the trial of peptonised food. The attempts hitherto made to prepare peptones and peptonised aliments for the sick have followed the gastric method, that is, the process with pepsin and hydrochloric acid. But so far the results have been disappointing. The difficulty lies in this. If you subject any native article of food—say milk, or bread, or meat—to artificial digestion with pepsin and acid, you utterly destroy the grateful odour and taste, and the inviting appearance, which made it desirable as food, and you convert it into a nauseous mess from which the human palate turns away with disgust. The unsavouriness of digested food is, however, not due to any ill taste or smell inherent in the peptones themselves—which, when purified, are both odourless and tasteless—but to a number of by-products of various kinds, volatile acids and other matters, which accumulate as digestion proceeds. One of these by-products is a bitter flavour, which is a constant and noteworthy characteristic of gastric digestion. I find it also associated with the later periods of pancreatic digestion, but in less intensity. The difficulty can be evaded by separating the peptones from the digested mass, and purifying them by repeated precipitation with absolute alcohol. But this process involves so much cost and labour, that it would preclude peptones so obtained from getting into general use.†

PEPTONISED MILK.—For some time past, I have been trying to attack the problem in another way. Last year, I found that extract of pancreas digested milk with great ease and with little apparent disturbance of its physical character. Milk, as you know, contains all the elements of a perfect food adjusted in their due proportion for the nutrition of the body. Two out of its three chief ingredients—namely, the sugar and the fat—are already in the most favourable condition for absorption, and require little, if any, further assistance from the digestive ferments. It is, therefore, obvious that, if we could change the casein of milk into peptone without materially altering the taste and appearance of the milk, such a result would go very near completely solving the problem of supplying a predigested food for the use of invalids. This consummation is still some way off; but the results already reached are, I think, susceptible of important dietetic application. You cannot, so far as I now know, completely peptonise milk without rendering it unfit for human food; but you can fractionally peptonise milk, that is, convert three-fourths or four-fifths of its casein into peptone without materially diminishing its agreeable qualities as an article of food. In order to understand this matter fully, I must ask you to follow me while I describe what occurs when milk is subjected to the process of pancreatic digestion. I cannot do this better than by describing an experi-

* This paper is the substance of an address delivered before a meeting of the Lancashire and Cheshire Branch of the British Medical Association, at Northwich, on April 26th, 1879.

† Dr. A. Adamkiewicz seems to have prepared fibrine-peptone on a large scale from purified blood-fibrine. He speaks of operating on hundredweights of fibrine. The peptone prepared by him from this source by the acid-pepsin process has been successfully used in feeding patients with intestinal obstruction.—*Natur und Nahrung der Peptons*. Berlin: 1879.

ment performed this forenoon, of which the results are placed in these phials before me. A pint of milk was diluted with half-a-pint of water, and after being heated to 120° F., was placed in a glass beaker with a tablespoonful of liquor pancreaticus and twenty grains of bicarbonate of soda. The beaker was then placed in a warm chamber, and maintained at a temperature of 110° F. until the close of the experiment. In about ten minutes, the milk was observed to thicken and become softly curdled. This phase soon passed away; the soft curds became dissolved; and in about half-an-hour from the commencement, the milk had recovered its diffident condition. Meanwhile, the milk had lost something of its glossy white appearance, and become a shade yellower. Very gradually, further changes took place; the milk got to look a little thinner and greyer; its flavour also progressively deteriorated, and at length became somewhat bitter and unpleasant. The process was completed, that is, all the casein was converted into peptone in two hours and a half from the commencement of the experiment. The milk no longer precipitated with acetic acid nor even with nitric acid. These numbered bottles contain samples withdrawn from the beaker at different periods and immediately boiled to prevent further changes. No. 1 represents the original mixture; No. 2 was removed in half-an-hour; No. 3 in an hour; No. 4 in two hours; and No. 5 at the end of the experiment. Nos. 1, 2, and 3 are scarcely distinguishable from each other, either in appearance or in taste; and yet I know, from other and parallel experiments, that in No. 3 at least three-fourths of the casein is changed into peptone. Nos. 4 and 5 are perceptibly altered in taste, but even these have nearly preserved their original milky appearance. The slight yellowing and greying just spoken of are not appreciable, except by comparison with a specimen of unaltered milk placed by the side of the digested samples. The series of changes do not cease with the completion of the peptonising process. The milk continues to deteriorate; and, in the course of some hours, it becomes more grey and watery-looking, and its taste becomes decidedly bitter and nauseous. It is important to know that you can arrest this series of changes at any point or at any moment by simply heating the milk to the boiling point. This at once destroys the activity of the ferments and puts an absolute check to all changes. It is also important to know that the greater part of the casein is converted into peptone soon after the commencement of the process, and that it takes a disproportionately long time to convert the remaining portion. Thus I found, when the experiment was so arranged that the milk was wholly peptonised in two hours and a half, that two-thirds of the casein was converted in the first half-hour and three-fourths in the first hour; and that it took an hour and a half longer to convert the remaining one-fourth. In this respect, the peptonising process followed the rule observed in many other ferment-actions; namely, that the gradually accumulating product of the ferment-action hampers the operation.

In preparing peptonised milk for invalids, it is absolutely essential to immediately boil the milk when the process has reached the desired point, in order to stop ulterior changes. It is, moreover, obvious that it is not necessary for a therapeutical purpose that the milk shall be completely peptonised. A milk in which three-fourths of the casein is digested, and which is so little altered in flavour that it can be taken like ordinary milk, would probably fulfil all the service capable of being rendered by fully peptonised milk. Such a result as this is, I believe, now within our reach. The rate at which milk can be peptonised by pancreatic extract—in other words, the time within which a given quantity of milk can be digested by this means—varies almost indefinitely according to the attendant circumstances. Four conditions have especially to be taken into account, namely, temperature, the degree of alkaliescence, the degree of dilution, and, above all, the quantity of the ferment. The higher the temperature, up to about 140° F., the quicker the digestion. The process is arrested and the ferment destroyed at 157°-158° F. On the other hand, a slow action takes place even in the cold. The process is hastened by increasing the alkali up to about four grains of the bicarbonate to each ounce of milk. An alkaliescence of one grain to the ounce of milk secures a sufficiently rapid action, and gives no appreciable taste to the product. A slower action takes place even in milk to which no alkali has been added. Dilution with water hastens the process greatly; it also facilitates it in another way. If the milk be diluted with one-third or one-half its bulk of water, the curdling phase is either altogether absent, or is usually so slight as not to amount to more than a transient thickening of the milk. In practice, I have, therefore, always found it advisable to dilute the milk beforehand, either with simple water or with a farinaceous gruel, so as to abate the tendency to curdling. This tendency varies in way I cannot always explain. Pronounced curdling delays the peptonising process very considerably, and thereby renders the product less acceptable to invalids.

The quantity of ferment that should be used is always a matter of

uncertainty. It is impossible to obtain pancreatic extracts of constant strength; and not only do several specimens of pancreatic extract differ from each other, but even the same specimen varies in activity according to its age. Freshly made extracts are nearly inert, and they go on increasing in activity for many months after they are made. But supposing you to be operating with the same sample, the proportion added to the milk greatly influences the rate of digestion. I have generally used a dessert-spoonful of the extract to the half-pint of milk. If the preparation be fairly active; this proportion yields a sufficiently quick result; and, in the case of the liquor pancreaticus, communicates no flavour. The glycerine extract perceptibly sweetens the milk, and is to some people disagreeable.

After a good many trials, I now advise the following procedure for preparing peptonised milk for the sick-room. A pint of milk is first diluted with half its bulk of water and heated to about 150° F. It is then put into a covered jug with a tablespoonful of liquor pancreaticus and twenty grains of bicarbonate of soda (in solution). The jug is then placed in a warm place under a "cosey" for one hour. At the end of this time, the milk is at once raised to the boiling point. It can then be used like any other milk, and undergoes no further change until decomposition sets in. It is well, however, to know that peptonised milk does not keep well, and that it should be used within twelve hours of the time of preparation. The use of the thermometer may be obviated by directing the milk to be diluted with an equal bulk of boiling water.

Another formula, which supplies a more nutritious product, and does not require the thermometer, is the following. To half-a-pint of cold milk, in a covered jug, add half-a-pint of well boiled and boiling gruel. This gives a temperature of 120° to 130° F. To this add a dessert-spoonful of the liquor pancreaticus and a dessert-spoonful of a saturated solution of bicarbonate of soda (which contains about ten grains). Put under a "cosey", as before, and heat to boiling at the expiration of an hour. In this case, the trypsin of the pancreatic extract acts on the casein of the milk and (I presume) on the gluten contained in the gruel. The diastase of the extract also acts on the starch of the gruel, and converts it into sugar. This method gives us a preparation similar in design to Liebig's food for infants, but in which the proteids, as well as the amylacea, are subjected to digestion. The making of it is exceedingly easy, and it would seem well adapted both for the nursery and for the sick-room. The gruel employed should be made thin; it may be prepared from wheat-flour, or from oatmeal, or from any other farina.

I have now used these fractionally digested articles of food in a considerable number of cases, and in many with gratifying results. If the process be properly performed, if it be cut short by boiling at the right moment—that is, after the curdling phase has passed away, and before ulterior changes have rendered the milk unpleasant to the palate—the resulting products are liked as well as if they were simple milk-and-water or simple milk-gruel. But if the process be carried too far—or if, on the other hand, the milk be still partially curdled when put before the patient—the product is not liked, and is even apt to cause nausea.

When further experience shall have taught us how to produce a pancreatic extract of constant strength, there will be no difficulty in exactly fixing the proper moment for stopping the ferment-action; meanwhile, the best rule is to allow the process to go on for an hour, and not longer. I have several times seen fractionally digested milk remain on the stomach when nothing else would remain. I have also seen this food tolerated without pain when all other food caused pain.

In the present state of this inquiry, it would not be prudent to say more on the therapeutical uses of peptonised milk and milk-gruel. Any practitioner can easily prepare these articles for himself, and make trial of them among his patients. The pancreatic extracts are made under the personal supervision of Mr. Benger,* who has spared neither time nor labour in their preparation, and who, by his skill as a practical pharmacist and his aptitude for experimental work, has rendered me invaluable aid throughout this investigation.

* F. B. Benger, of the firm of Mottershead and Co., Chemists, Manchester, from whom these preparations can be obtained.

BATH.—During the second quarter of the present year, the death-rate of this city was 20.8 per 1,000, as against 23.9 in the corresponding quarter of 1878. The total number of deaths were 280, of which 57 were under five years of age, and 124, or not very far from half, over sixty years of age. The deaths above eighty years were 34, or about an eighth of the deaths. The zymotic fatality was remarkably low (0.8 per 1,000). In the early part of the year, there was a smart outbreak of scarlet fever; but its progress was effectually checked by the isolation afforded by the infectious hospital.