LETTSONIAN LECTURES ON DISORDERS OF DIGESTION: THEIR CONSEQUENCES AND TREATMENT.

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MR. PRESIDENT AND GENTLEMEN,—I thank you most sincerely for the honour you have done me in appointing me to deliver the Lettsonian Lectures before you this year. The subject I have chosen is one of much practical interest, but it is of such extent that, to deal with it completely, in a course of three lectures, is obviously impossible. I have already discussed the physiological processes of digestion at considerable length elsewhere,¹ and I have therefore less hesitation in passing over those which are well known, with a few general remarks, and dwelling at greater length upon some points which are not so fully described in text-books, although they have important bearings on the practice of medicine.

Man has been defined as a cooking animal. This definition may not be absolutely correct, and there may be some of the lowest races unacquainted with methods of cooking, although other characteristics entitle them to be called men. Yet the definition is, in the main, true; and the fact that man cooks his food, while the lower animals eat theirs raw, is one of the most marked distinctions between him and them. The practice of cooking was familiar to man at a very early stage indeed of his history. Long, long before the historic epoch, when man's only implements consisted of broken flints, he cooked his food by roasting; and the charred remains of bones, which he had roasted in order to enjoy the savoury marrow, have been found in caves, along with fragments of the skeletons of the cave-bear, woolly rhinoceros, and other animals long ago extinct. There is little doubt that roasting was the first method of cooking adopted, for no implements were required, beyond a piece of pointed stick, to hold the food in front of the fire. Boiling is a considerably more complex process, and requires a vessel in which to hold water. This vessel need not necessarily stand fire, because the simplest method of boiling, and the one which was probably first adopted, appears to be that of heating the water by putting red hot stones into it, until the temperature is sufficiently raised. But after man learned to make pottery, and to bake it in the fire, so that heat could be applied from the outside without the vessel cracking, the simpler plan of boiling the water by putting the earthen pot upon the fire, would be sure to be followed; for man, as a rule, likes to save himself trouble, and usually takes what seems to him to be the easiest plan.

Amongst the various pots of earthenware, early man must have noted the same differences that we do now. We see some pots of thoroughly baked earthenware so hard and strong as to resemble stone; and, indeed, in the case of a Wedgwood mortar, the earthenware is more resistant than almost any stone. Other pots we see of fine china, thin and fragile, which must be handled with the greatest care, lest they break under our fingers. Yet both vessels are equally whole. Turn them round and round, and scan them most minutely, and yet you will find no flaw in either the one or the other. There is no difference between their wholeness, or wholth, or, as we now write it, health; yet the wholeness or health of one vessel is strong, and the wholeness or health of the other is weak. The one may be put to all sorts of purposes, subjected to all sorts of treatment, meet with all sorts of rough usage, and yet it will remain whole or healthy. The other remains whole only so long as it is treated with the greatest care; the slightest rough usage will crack or break it, and then its wholeness or health is gone. Our early forefathers, when framing a language by which to communicate with one another, had evidently been struck by an analogy between the implements they used in cookery, hunting, or warfare—those implements by which they maintained the life of their bodies, and those bodies themselves; for they applied the word health to signify soundness in both. At the present

day, we sometimes forget the derivation of our word health; but still we are accustomed to qualify it by the adjectives strong and weak, in much the same way as one might speak of the soundness of an earthenware pot. By strong health, we mean a soundness of body which, like that of a Wedgwood mortar, will enable a person possessing it to go through all sorts of work, be subjected to all sorts of usage, and yet remain sound or healthy. By weak health, we mean a condition of body wherein all the functions go on perfectly so long as external circumstances are favourable, in which the person is fitted to do certain work, and will do it perfectly, provided the calls made upon him be not too great for his strength; but, if he be subjected to any extraordinary exertion, any unusual exposure, or rough usage of any kind, the feeble organism at once breaks down, and is damaged or destroyed. Not infrequently we find that a strong earthenware pot, subjected to very rough usage, is cracked; but the crack, instead of completely destroying it, reduces it only from a condition of strength to weakness; so that it remains to a certain extent whole, but is now weak; so that, unless treated with care, it will readily break, although, if tenderly handled, it may continue useful for a long time. We find a similar condition also in man; and what was originally strong health in a person may be so weakened by exposure, overwork, or the consequences of acute disease, that the health becomes permanently weak, instead of strong.

Health in man, as in other animals, depends upon the proper performance of all the functions. These functions may be shortly said to be three: (1) tissue-change, (2) removal of waste, (3) supply of new material. For the activity of man, like the heat of the fire by which he cooks his food, is maintained by combustion; and just as the fire may be prevented from burning brightly by improper disposition of the fuel, or imperfect supply of air, and as it will certainly go out if fresh fuel be not supplied, and may be clogged by its own ashes, so man's activity may be lessened by imperfect tissue-change, and may be put an end to by an insufficient supply of new material and imperfect removal of waste products. It is with the supply of new material that we have to concern ourselves chiefly in the present lectures, although it is so closely associated with tissue-change and removal of waste, that we shall be obliged to consider these also to a certain extent. The old proverb, "There is many a slip 'twixt the cup and the lip," shows how clearly our forefathers recognised that neither food nor drink was available for the wants of the body until it had actually been taken. Our knowledge carries us a step further than theirs; but even yet we are very apt to forget that both food and drink are useless for the wants of the organism, so long as they are simply in the intestinal canal. The body may be roughly compared to a cylindrical box, through the centre of which runs a tube, open at both ends, but not communicating with the cavity of the box. Here, it is evident, that anything put into the tube remains as much outside the box as if it were laid against the outer surface. If the tube be of a different material from the outer wall of the box—if, for example, it be more pervious, liquids, or finely divided powders, might pass more readily from the tube through it into the box, than they would from the outer wall; but so long as they did not pass through in this way, they would remain, to all intents and purposes, outside the box; and this is the case with the intestinal tube.

Food and drink, when swallowed, are still outside the body, and in certain circumstances remain so just as much as if they had been laid against the skin. For we sometimes find that food which has been swallowed passes through the intestine, and is evacuated almost or entirely unchanged. It has simply fallen, so to speak, from the mouth to the anus, much as it might have fallen from the neck to the feet, if it had been laid against the skin. There is one great difference between the skin and the intestine, namely, that the nerves of the intestinal tract are more sensitive than those of the skin; and in passing over the mucous membrane the substance may have exercised a greater action on the body, reflexly through the nerves, than it would have done in passing over the skin; but otherwise the condition in the two cases is much the same. The epidermis also, which covers the skin, is much harder and less permeable than the epithelial covering of the mucous membrane lining the alimentary tract; and, therefore, liquids applied to the skin remain unabsorbed, while usually they pass pretty readily into the body from the alimentary canal. Solids in a very minute state of division, and especially when mixed with fat, may be absorbed by the skin, as we see in the case of inunction with mercurial ointment, where the minutely divided globules of mercury pass through the skin, are absorbed into the circulation, and are carried by the blood to the various parts of the body. It is most probable, although authorities are not completely agreed upon the subject, that solid particles in a minute state of subdivision are also absorbed by the mucous membrane of the alimentary canal; but the

¹ "Digestion and Secretion," forming Part III of Sanderson's *Handbook for the Physiological Laboratory*, 1873. London: Churchill. This Part has been revised for the French translation by Professor Moquin-Tandon, 1884. Paris: Felix Alcan.

greatest part of the food is absorbed, not in a state of simple minute subdivision, but in a state of solution.

In the alimentary tract, we have provision made both for solution and for absorption, and those two processes are included under the term digestion. Digestion, like the health generally, may be strong or weak. Some persons are able to take with impunity quantities of fat, pastry, cheese, raw apples, and various kinds of indigestible food, which in other persons would cause discomfort, pain, vomiting, or diarrhoea. Some are able to take meals at all sorts of irregular hours, to do hard work for a whole day without food, and then consume an enormous dinner, to go through all sorts of anxiety without the least diminution of appetite, and to drink all sorts of strong liquors without appearing to be any the worse. Others, again, suffer if their meals are not served exactly at the usual times; a little extra work or a little anxiety will either destroy their appetite or impair their digestive power; a meal somewhat too hearty, or the slightest indulgence in wine or alcohol, is sure to be followed by unpleasant consequences. Yet even those persons may go on for months and years with comfort, digesting their food perfectly, provided only that they take care to fulfil the necessary conditions. Their digestion is healthy, but it is weak.

When digestion is imperfectly performed, we say that the patient suffers from indigestion. Indigestion may occur in those who habitually have either a strong or a weak digestion, and by proper methods it may frequently be cured in both; nay, more, we may sometimes be able to strengthen the naturally weak digestion, though we can hardly expect to alter the natural constitution of the patient, so far as to enable a man who has naturally what is called "a weak stomach" to compete with one who has naturally the digestion of an ostrich, at a civic feast or at a succession of private dinners.

We have already compared the food by which man's activity is sustained to the fuel which keeps up a fire; but this comparison is not altogether correct, for man is a complex machine, the different parts of his body require different materials, and the wear and tear of each must be replaced by its appropriate constituents, as well as energy supplied to the whole. A steam-engine not only needs fuel to keep it going, but metal to replace the wear and tear of its parts, and oil to lessen the friction of the various parts upon one another. No doubt some of those various necessities may be replaced by others, and we might, for example, use oil instead of fuel; but this would be a wasteful and expensive proceeding. Similarly, a mixture of foods is best adapted to supply the energy and repair the waste in the human body. Like the steam-engine, we require oils or fats and proteids, which go, in a great measure at least, to repair the wear and tear of the tissues; carbo-hydrates, which may be looked upon as like coal supplying energy to the organism by their combustion. These various kinds of food are required in different proportions. According to Ranke, about 100 grammes of proteids and a similar quantity of fats are required daily by a man, while two and a half times as much, that is, 250 grammes, of carbo-hydrates are necessary. Very few substances indeed will supply the requisite ingredients in proper proportion for the wants of the body, and so we usually employ a mixed diet. Black bread contains very nearly the proper proportion of nitrogenous and carbonaceous materials, and, when taken along with a little oil or a few olives, it may maintain a man in health and activity, without the addition of almost anything else except a little salt, as is seen amongst the hard working peasantry in the south of France.

In this country we have generally a more varied diet, and, as a typical meal, we may take a beef-steak with a piece of fat attached, a piece of bread, some salt and water. The beef-steak supplies fat and proteids, the bread supplies carbo-hydrates, and the salt and water make up the requisite constituents of food. But the beef-steak and bread cannot be absorbed in their solid condition; and unless they be absorbed, as I mentioned before, they are of no use to the body; nor is it sufficient merely to reduce them to a minute state of subdivision, they must be dissolved. The salt which we eat with the beef-steak dissolves in the water without more ado; but the beef-steak itself and the bread will not dissolve without first undergoing some change. In all processes of solution, the first thing to be done is, if possible, to get the substance which is to be dissolved into a state of minute subdivision.

If we take coarse salt in large crystals, it dissolves slowly as compared with table-salt in fine powder, and we accelerate its solution very much by breaking it up, and by stirring it through the water. If we allow it to remain at rest, the layer of water in contact with it soon becomes saturated, and the process of solution goes on slowly, whereas, by stirring, we bring the particles of salt constantly into contact with unsaturated water, and thus solution goes on quickly. In the process of solution, the particles of salt become

separated from each other by the water, but the process is a physical one; each particle still continues to be salt, and if the water be removed by evaporation, the residue is salt just as it was at first. During digestion, a similar process occurs in the case of proteids and carbo-hydrates, but it is carried a step farther. Not only do the particles of proteids and carbo-hydrates become separated from one another by the water, but it penetrates into the chemical molecules of which they are composed, so that a chemical change of hydration occurs, and the large chemical molecules of the proteids and carbo-hydrates split asunder into smaller and simpler ones.

In breaking down the beef-steak or the bread mechanically, we see that we are able to make the particles of which they consist smaller and smaller, until, perhaps, we may be barely able to see each particle with the naked eye. But the process of subdivision does not stop at the limits of our vision, nor even at the limits of our highest microscopic powers. In a perfect solution, the most powerful microscope will fail to discover any particle, and yet we are able by certain methods not only to show the presence of particles, but even to judge of their size. We estimate the size of particles that we can see, by the size of the mesh in a sieve through which they will pass, and, by a similar method, we are able to judge of the size of the molecules of chemical substances.

Graham showed that some bodies will diffuse through an animal membrane, others will not. Those that diffuse are generally crystalline, those that do not are generally non-crystalline; but it is probable that the connection between crystallisation and diffusion is to be regarded as accidental rather than necessary, and the real cause why some substances diffuse and others do not, is that the molecules composing them differ much in size.

In experiments on diffusion through artificial membranes, Moritz Traube found that a membrane of tannate of gelatine would allow nitrate of barium, with a molecular weight of 130.6, to diffuse through it, and would also allow the passage of all compounds having a smaller molecular weight, but it stopped the passage of ferrocyanide of potassium, having a molecular weight of 211.4. (Moritz Traube, *Centralblatt für die Med. Wiss.*, 1866, p. 114.) Membranes may thus be regarded as atomic sieves; and if one substance will not diffuse through a membrane which will allow another to pass, we may consider that the molecules composing the substance which diffuses are smaller than those of the other. This view has an important bearing, as we shall afterwards see, on the causation of certain forms of albuminuria. It is supported, not only by the experiments of Traube on artificial membranes, but by the behaviour of hæmoglobin in regard to diffusion.

Crystalline bodies are, as a rule, diffusible, but they are usually also of much lower molecular weight than organic uncrystalline bodies. There is one crystalline substance—hæmoglobin—which will not diffuse, but it has a very high molecular weight, and probably the chemical molecules of which it consists are very large.

In the process of hydration, the molecules of albumen and of starch do not split down all at once into the smaller molecules to which they may be ultimately reduced by the action of digestion. Between the large molecules forming the myosin and starch of the beef-steak and bread, and the small ones of peptone and maltose into which they are transformed during digestion, there are a number of intermediate products. In these products, the molecules are probably of varying size, and they diffuse with various degrees of rapidity. Thus the large molecule of starch breaks down, first into dextrine, and then into sugar. The large molecules of albuminous materials or proteids, including in this term ordinary albumen or white of egg, cooked meat, the casein of milk or cheese, and the vegetable casein of wheat or peas, break down into intermediate substances termed antialbumose, hemialbumose, antiptone, and hemiptone, before they are finally converted into peptones. There is less necessity for the molecules of fats to be broken down chemically, because, as we have seen, fats are absorbed even by the skin, and they seem to pass through the mucous membrane of the intestines, and become absorbed, even without decomposition. Their absorption is, however, aided by their being reduced to a fine state of subdivision or emulsion, and this minute subdivision occurs all the more readily by a partial decomposition into fatty acid and glycerine occurring in the digestive canal. The presence of a slight trace of fatty acid greatly aids the formation of an emulsion; and, as we shall presently find, decomposition of fats, with liberation of fatty acid, does occur in the process of digestion.

It may be worth while now to take a short survey of the digestive processes, although time will not allow us to enter at all fully into them.

The first part of the digestive process in man is a very important one, and one which does not receive anything like the amount of at-

tention which it ought ; it is the process of mastication. As I have already mentioned, whenever we wish to dissolve anything rapidly, we must comminute it finely. All the food should, therefore, be thoroughly broken up in the mouth. Thorough mastication not only subdivides the food mechanically, but the saliva, which is secreted under the two-fold stimulus of the taste of the food and the movements of mastication, tends to dissolve such parts of the food as are soluble in water, and to convert the insoluble parts into a pulp. At the same time, the diastatic ferment of human saliva begins to convert the starch of the food first into dextrin, and then into malt, sugar, or maltose. This conversion goes on very rapidly ; and if one chew a piece of stale bread, even for a couple of minutes, a distinctly sweet taste will usually be perceived from the formation of sugar in the mouth. But the effects of mastication are not limited to the changes produced by it in the food within the buccal cavity ; the taste of savoury meat, the rolling of a sweet morsel under the tongue, and the movements of mastication, exert an influence upon the stomach and upon the brain. In a case of gastric fistula, where the œsophagus was completely occluded, Richet noticed that the mastication of food induced secretion of gastric juice, although nothing could pass from the mouth into the stomach on account of the obstruction in the gullet. It is obvious that the secretion, both of saliva and of gastric juice, takes place reflexly through the medium of the nerves ; and if the nervous system be dull or depressed, the stimulus of food in the mouth is not likely to excite secretion to the same extent as when the nerve-centres are active. But provision seems to have been made for this ; and the mere act of mastication not only supplies a stimulus to the peripheral ends of sensory nerves in the mouth, it leads to an increased supply of blood to the nerve-centres. This is well shown by some observations of Marey, who found that the current of blood in the carotid artery of a horse became three times as rapid during mastication as it was before. No doubt, part of this increased supply of blood went to the salivary glands and to the muscles of mastication ; but it is almost certain that a part of it went also to the nerve-centres. Even if one should deny that any part of the extra current of blood in the carotid, which is consequent upon mastication, goes to the brain, the fact would still remain that the movements of rolling the morsels about in the mouth, and sucking their sweetness and savour, increases the circulation in the brain, for this has been actually observed by François-Franck in the human subject.

When the food has been thoroughly masticated, it is swallowed, and the act of swallowing sets in action a mechanism which is calculated to increase the blood-supply, not only to the nerve-centres, but to all the glandular structures concerned in the digestive tract. Kronecker has discovered that the act of swallowing seems to remove entirely the inhibitory action of the vagus nerve upon the heart, for the time being, so that the pulse becomes exceedingly rapid. The extent to which this occurs will hardly be credited by any one who has not tried the experiment. In my own case, I find that sipping half a wine-glass full of water, will raise my pulse from 76 to considerably over 100. Hence, in fact, a glass of cold water, slowly sipped, will stimulate the heart as much as, or more than, a glass of brandy swallowed at a draught.

When the food arrives in the stomach, it will, if mastication have been properly performed, and the digestive fluids have been properly secreted, find a supply of gastric juice already in the stomach, and this will continue to increase in quantity during the progress of the meal. The alkaline saliva swallowed with the food will act as a further stimulus to the secretion of the acid gastric juice ; but soon the quantity of acid will be sufficient not only to neutralise the alkali, but to leave a little acid over. The amount of free acidity is, however, very slight, because the hydrochloric acid which the gastric juice contains combines, for the time being, with pepsin and proteids, forming a compound which does not give an acid reaction. The starch, which has begun to be converted into dextrin in the mouth, undergoes still further conversion by the saliva which has been swallowed. It has not yet been definitely settled whether or not the action of the saliva is so far arrested in the stomach as to prevent the formation of more sugar ; but, at all events, it appears to be certain that dextrin is formed, and this is a fact of very considerable importance, as we shall see when we come to consider the order in which food is usually taken at meals. Albuminoids, or proteids, under the action of the gastric juice, swell up, and are more or less completely dissolved. The large and complicated molecules which compose them appear, as already mentioned, to be broken up into simple ones by a process of hydration. First of all, they appear to form a compound with acid, termed syntonin, or acid albumen. This is soluble in acid, but when the solution is neutralised the albuminoid is again precipitated. The next stage appears to be the formation of a body known as propeptone, hemialbuminose, or parapeptone. This body is not coagulated by heat,

and is soluble in water in the presence of weak acids or alkalies. It is precipitated by nitric acid, but when the mixture is heated it dissolves, and a precipitate forms again on cooling.

The last stage is the formation of true peptones, which are not coagulated by boiling, nor by nitric acid, nor by acetic acid and potassium-ferrocyanide. They diffuse very easily through animal membranes, and in this respect they differ very greatly from other forms of albumen. By dissolving albuminous substances in artificial gastric juice outside the body, we can produce peptones, and these are sometimes of great service as nutrients in disease. We almost always notice that the product of such artificial digestion has a disagreeable bitter taste. The cause of this bitterness has not yet been thoroughly investigated. We know, however, that amongst the strongest bitters with which we are acquainted are some of the organic alkaloids ; for example, strychnine, the bitterness of which can be perceived in extremely dilute solutions. Now, the organic alkaloids are, to a certain extent, related to albumen, inasmuch as they both belong to the aromatic series of organic compounds, and several alkaloids have been obtained from decomposing albumen. To these alkaloids the name of ptomaines has been given. This relationship between alkaloids and albuminous substances would almost lead us to suspect that the bitterness developed during gastric digestion might be due to the formation of an alkaloid. As I have already said, it is not certain that this bitter substance is an alkaloid, but it is certain that an alkaloid has been obtained from peptones formed by gastric digestion by Brieger. By extracting a quantity of gastric peptones with amylic alcohol, he obtained an alkali free from peptones which had an action like that of curara.

Every effect has a cause, if we can only find it out ; but we not unfrequently ascribe effects to the wrong causes, and perhaps this may be the case with regard to the activity of the pylorus. While the food remains in the stomach, it is mixed up thoroughly with the gastric juice by a sort of churning movement of the gastric walls of the stomach, the pylorus remaining contracted, so as to prevent the gastric contents from escaping in any large quantity into the duodenum.

At the end of three or four hours, however, the pylorus relaxes, and the chyme escapes out of the stomach into the duodenum. This alteration in the behaviour of the pylorus, at the end of a certain time, has been ascribed to the increasing acidity of the chyme ; but this seems a little doubtful, inasmuch as we frequently notice cases of abnormal acidity, where the food is retained in the stomach for an excessive time, instead of being passed on too rapidly to the intestines. This is a point upon which we are at present quite unable to speak with any certainty ; but the discovery that an alkaloid is formed during the process of digestion in the stomach opens up a new field of inquiry, and may lead us to ask whether the different behaviour of the stomach, at the end of three or four hours, is not due to the action of this alkaloid upon it.

During the process of digestion in the stomach, fats become partially decomposed, and a small quantity of fatty acids are formed, which aid in emulsifying the remainder of the fat. When the chyme passes through the pyloric orifice into the duodenum, it meets with the bile and the gastric juice. These neutralise the acid chyme, and render it alkaline. The further action of pepsin is thus prevented, and the albuminous substances, which have only been converted into syntonin, or acid albumen, are precipitated. The pancreatic secretion is the most energetic and general in its action of all the digestive juices ; it unites in itself the action of the saliva and the gastric juices, besides having properties of its own. Like the saliva, it converts starch into dextrine and sugar, and it finishes the work which the saliva had begun.

Like the gastric juice, it dissolves albuminous bodies, forming peptones, though it does not dissolve them in quite the same way. The gastric juice causes them to swell up before they dissolve. The pancreatic juice attacks them from the outside, and makes them crumble away. We do not yet know whether there is any distinct difference between the peptones formed by the action of the pancreatic and gastric juices, but it seems not at all improbable that differences should exist. In addition to its action on starch and albuminoids, the pancreatic juice emulsifies fats, and tends to split them up into fatty acids and glycerine. This emulsifying action is aided by the bile, which appears to have a considerable power to facilitate the passage of fat through animal membranes. This can be readily shown by trying to make oil pass through an animal membrane wetted with water, and another similar one wetted with bile. The oil will pass through the latter much more readily than through the former. The action of bile in dissolving fats is indeed popularly known, and it is used for removing oil-stains from articles of furniture. In an examination on physiology some years ago at South Kensington, the question was put

"What is bile, and what are its uses?" One candidate's answer was, "Bile is formed in the stomach, and is used for cleaning carpets." The knowledge of physiology displayed by this student was somewhat inaccurate, to say the least of it; but his answer may serve to impress upon our memories the fact that bile has the power not only of removing stains of grease from the surface of vegetable fabrics like carpets, but of enabling oil to pass through animal tissues, such as mucous membranes. But the bile has another very important function: it tends to prevent putrefaction. Now the minute vegetable organisms which give rise to putrefaction are to be found almost everywhere; and they pass into the intestine with our food and drink. The healthy stomach, with its acid secretions, does not afford them a suitable nidus, but the products of pancreatic digestion seem to form a soil especially favourable to their development. If we digest a piece of meat with pancreas for twenty-four hours, at the temperature of the body, we usually find that not only has the meat become dissolved, and peptones formed, but that the peptones themselves have undergone a further decomposition, and that leucin, tyrosin, naphthylmin, and a substance termed indol, nearly allied to indigo, but with an abominable smell, have been formed. Indol is not the product of the decomposition of nitrogenous matter by the pancreatic ferment; it is due to the presence of putrefactive bacteria.

The same changes which occur in pancreatic digestion outside the body may, and sometimes do, occur inside the body. In health, their occurrence is probably rather the exception than the rule; but, were it not for the antiseptic action of the bile, their occurrence would probably be the rule, and not the exception. It may seem, perhaps, that the occurrence of putrefaction might not be of any great consequence; but when we remember that, during putrefaction, organic alkaloids which have a poisonous action are formed in the body, it is evident that, if putrefaction take place to any great extent in the intestine, there may be a risk of actual poisoning by the absorption of organic alkaloids formed in the intestinal canal.

From the duodenum onwards to the rectum, the reaction of the intestinal contents remains alkaline, and so there is nothing to arrest the further action of the pancreatic ferments. The action of the intestinal juice on the food is not as yet perfectly understood, and various conflicting statements have been made regarding it. One reason of this probably is, that the action of this juice has been tested upon the raw constituents of the food, and not upon foods which have already been altered by exposure to the action of the gastric and pancreatic juices. The intestinal juice is said to have no action on coagulated albumen, and this appears to be the case; but, when I was working in his laboratory at Amsterdam, Professor Kühne informed me that intestinal juice would dissolve coagulated fibrine, which had been previously rendered soluble, but not peptonised, by pancreatic juice.

In its course through the large and small intestine, the portions of food which have been rendered soluble by digestion are gradually absorbed by the veins and lymphatics, and carried into the general circulation. Almost immediately after entering the blood-vessels, changes appear to occur in the peptones. These appear to be taken up, to a great extent, by the red blood-corpuscles, and converted by dehydration into a larger and more complicated albuminous molecule, namely, that of globulin. The blood-corpuscles thus form, as it were, a store of albuminous material, which they convey to all parts of the body, and give off where it is wanted. But the whole of the peptones do not appear to undergo this change; part of them appear to be arrested in the liver, and to form glycogen, as it has been found that the quantity of glycogen in this organ is increased by the injection of peptones into the bowel. The sugar also becomes dehydrated, and glycogen is produced from it likewise. This is stored up in the liver for a variable time, and then gradually given out again to supply the wants of the organism. The liver, therefore, acts as a wise steward, laying by provision for the organism in the times of plenty, after a full meal, and giving it out again in times of fasting. But this is not all.

We know that one of the most striking points in the action of such powerful poisons as the venom of vipers and curara is that, though deadly when injected into a wound, they are almost completely innocuous when swallowed. We know that one reason of this is, that they reach the general circulation much more slowly from the intestine than from the wound, so that the kidneys have time to excrete them, and prevent their accumulating in the blood. It is the liver which is the chief agent in retarding the absorption of poisons into the blood, and thus rendering them comparatively innocuous when they are introduced into the intestinal canal. All the blood from the stomach and intestines must pass through the portal vein before it can reach the general circulation; and, as our forefathers recognised by the name they gave it, to the porta or gate of the liver the hepatic

tissue acts the part of a prudent porter at the gate, and turns back or destroys dangerous intruders. Poisons injected into the duodenum are absorbed into the portal vein; but they are removed from the blood by the secreting tissue of the liver, and poured back with the bile into the intestinal canal. Again, they may undergo re-absorption, and round and round they may go in a circle, from intestine to liver, and from liver to intestine again, without ever being able to pass into the general circulation, or produce any direct effect upon heart, lung, brain, or kidneys.

But even this is not all. The liver actually destroys some organic poisons, such as nicotin; and, were it not for the faithful performance of its duty, we would be in danger of poisoning by every meal we take. For Ludwig and Schmidt and Mülheim have found that peptones, when injected into the general circulation, act as poisons, producing loss of coagulability in the blood and great depression of the circulation. We see, then, that the products even of healthy digestion might prove fatal if they passed rapidly into the general circulation; and it is still more likely that such an effect would follow the absorption of the products of the putrefaction which occurs in cases of indigestion. Were it not for this power of the liver to obstruct the passage of poisons, and actually to destroy them, the alkaloids formed either by normal digestion or by abnormal putrefactive process in the intestine might readily pass to the heart, nervous system, and kidneys, and cause dangerous or fatal consequences.

The function of watching over the safety of the organism is not confined, however, to the liver, but is shared by other organs. The liver acts as a porter to prevent injurious substances from passing from the intestine into the blood, but the tongue and palate are the porters which prevent obnoxious substances from being taken into the intestinal canal. As a general rule, though by no means without exception, substances pleasing to the palate are useful and not injurious to the organism. The nerves of taste, like those of sight and hearing, are nerves of special sense, and are capable of education. But, while we usually regard the education of the senses of sight and hearing as a noble thing, we are too careless of the education of our taste, and look upon it rather as something degrading. Yet the education of the nerves of taste should be considered in the same light as that of the other special senses; and cookery, has, I think, a perfect right to be ranked with music, painting, sculpture and architecture as one of the fine arts. The difference between cookery and music, or painting, is, that while the objects which give rise to sight and sound remain outside the body, we are obliged to swallow the substances which excite sensations in our nerves of taste. It is not quite sufficient to turn them over in the mouth and put them out again, because the full sensation is only obtained just in the act of swallowing. For this reason, devotees to the art of cookery must either be content with a moderate enjoyment of the pleasures of taste, or consent, like some of the Roman emperors of old or German students of the present day, to eject again the food or drink which they have already taken and enjoyed. Only rarely does one meet with a dinner which gives one the sense of high artistic perfection, although I remember having partaken of one such when enjoying the hospitality of a city company. Each course seemed to excite an appetite for the one which succeeded, and was accompanied by a wine so carefully selected that it gave zest to the food, while the food appeared to give additional flavour to the wine.

This dinner was a revelation to me; it not only showed me that cookery might rank as one of the fine arts, but taught me that it might be a powerful moral agent. I went to the dinner exhausted with overwork, irritable in temper, and believing that city companies were wasteful bodies, who squandered money that might be employed for useful purposes, and that they should be abolished; I came away feeling strong and well, with an angelic temper, and firmly convinced that city companies had been established for the express purpose of giving dinners, and ought on no account to be interfered with. Nor was the good thus effected of a transitory nature; the irritability of temper, which had disappeared in the course of dinner, did not return; and the morning afterwards, instead of awaking with headache and depression, I awoke strong, well, and ready for work, and remained so for a considerable length of time. Nor do I think that mine is a solitary case. A succession of heavy dinners is, no doubt, injurious; but when the organism is exhausted, a good dinner, with abundance of wine, is sometimes of the greatest possible use. But there is one condition which must not be neglected, or otherwise the consequences will be anything but satisfactory: the dinner must be well cooked, and the wines must be thoroughly good.

It is, as I have said, only occasionally that one meets with real high artistic cookery. But, even in the courses of an ordinary dinner, an order is adopted which is thoroughly physiological, and which shows

that, whatever men may be in other things, they are not "mostly fools" in regard to the plan of their meals.

The common order of courses in a plain dinner is soup, fish, joint, pudding, bread and cheese, and dessert. The reason why soup comes first, has been admirably shown by Schiff in his experiments on digestion. This physiologist found that the stomach of an animal which some time before had digested a full meal, had very little power to digest albumen introduced directly into it; and a similar fact was ascertained in regard to an extract made from the stomach itself, this extract hardly acting on albumen at all. The stomach seemed to be exhausted by the effort of digesting a full meal several hours before, and to be incapable of producing pepsine. But if certain substances were introduced first into the stomach, the power to digest albumen was enormously increased. To these substances Schiff gave the name of "peptogens," and the most powerful of them he found to be dextrin, and soup made from meat.

If the human stomach resembles the stomachs of animals in this point as it does in others, then we may say that usually the power of the stomach to digest such substances as hard boiled eggs or boiled meat, when these are taken alone, will be very slight. But if the meal be begun with a plate of soup and a piece of bread, the bread partly converted into dextrin in the mouth, and the extractive matters of meat contained in the soup, on reaching the stomach, will be absorbed, and will supply to the gastric follicles the power to secrete an abundance of pepsine. In this country, where our butcher's meat is tender and juicy, we not unfrequently find that people in the middle of the day will take a beef-steak or a mutton-chop without soup. In this case, the savoury soluble substances are quickly extracted from the meat in the stomach itself, and, being absorbed, supply the necessary secreting power to the gastric glands. But in other countries, where the animals slaughtered for food are often old and tough oxen, which have been employed for years in agricultural service, the meat, being less savoury and juicy, will not yield peptogenic matters so readily to the stomach. Consequently, the Frenchman generally boils his butcher's meat thoroughly, and adds pieces of bread to the soup with which he begins his meal, so that the stomach can absorb sufficient peptogenic substance before the hard and tasteless boiled beef is swallowed.

Next to the soup, as I have said, usually comes fish, which is digested more easily than butcher-meat. I have already mentioned, more than once, that the rapidity with which anything dissolves depends very much on the fineness with which it is divided. Now, this is quite true of the different kinds of meat. Beef is acknowledged to be less digestible than mutton, and mutton less digestible than fish. The breast of a chicken is also reckoned very digestible. If we compare these different kinds of flesh, we will find that in beef the fibres are longer and harder than those of mutton, and those of mutton longer and harder than those of the breast of a fowl. The muscle-fibres in fish are arrayed in flaky masses, and are not only very short, but are very readily separated from one another. We see, then, that the different digestibility of these different kinds of meat corresponds exactly with the readiness with which the muscle-fibres can be broken up mechanically. That it is the physical conformation of the muscle-fibres, rather than anything peculiar to the animal from which they are derived, is shown, I think, by the fact that, although the breast of fowls is universally acknowledged to be readily digestible, the legs, in which the muscular fibres are long and hard, are by no means specially adapted for weak digestions. With the meat, come vegetables, which are not only useful as supplying inorganic salts, but probably play a considerable part in aiding the recomposition of peptones into albuminous material of the tissues, after their absorption. After the meal come the bread, cheese, and dessert. The bread will, no doubt, supply additional dextrin, and the cheese additional albuminoids; but, if we direct our attention only to the stomach, and to the chemical changes which are going on in it, it is not quite easy to see why bread, cheese, and dessert should be taken at the end of dinner. If we turn our attention, however, to the circulation and the nervous system, and remember the effect which I have already mentioned as produced upon them by the mastication and deglutition of savoury food, we can at once see a good reason for the common manner of terminating a dinner. In order to supply abundant gastric juice for the digestion of the food introduced into it, the stomach requires an abundant supply of blood, and the nervous system must be kept active in order to respond to the calls made upon it. The savoury cheese, swallowed in small morsels, and the sweet fruits, which strongly stimulate the nerves of taste, or nuts, which require considerable mastication, cause an abundant flow of blood to the nerve-centres; while the frequent movements of swallowing stimulate the heart, and increase the rapidity of the general circulation.

In the case of ordinary meals taken by a healthy man, the food is

quite sufficient to stimulate the various parts of the digestive canal, the nervous system, and the circulation sufficiently to insure complete digestion. But if the meal be more than ordinarily heavy, if the person be exhausted by long fasting, by severe exertion, or have a weak digestion, other aid must be invoked. One of the most powerful stimulants, both to secretion and the circulation, is alcohol; and we find that persons of weak digestion sometimes take sherry and bitters before a meal, or take a glass of sherry with their soup. During the course of a meal, an effervescent wine like champagne is taken, the carbonic acid of which will stimulate absorption, while at the end a powerful stimulus is applied in the shape of a small glass of brandy or liqueur; and during dessert a quantity of wine is sipped, so that the effect of the sipping already mentioned upon the circulation and nervous system are combined with the action of the alcohol and ethers contained in the wine.

Provided that all those parts of a meal have been taken in moderation—and when we speak of moderation, we must always remember that this is a relative term: what is moderation for a man of strong digestion is excess for a man of weak digestion—provided, then, that moderation has been exercised, no harm will result even from a heavy meal. But if the food have been excessive in quantity, or injurious in quality, and more especially if alcoholic stimulants have been taken in excess, the stomach will suffer, and, next day, the symptoms of gastric indigestion will probably appear. The most marked of these are loaded tongue, loss of appetite, tendency to nausea, and, perhaps, even vomiting. The condition of the stomach, corresponding to these symptoms, was ascertained by Dr. Beaumont in the case of Alexis St. Martin. On looking into the interior of St. Martin's stomach, during the occurrence of such symptoms as these, Dr. Beaumont found "that several red spots and patches abraded off the mucous coat, tender and irritable, appeared over the inner surface." In such congested and irritable conditions of the stomach, the gastric juice secreted appears to have an alkaline, rather than an acid, reaction, and consequently to have comparatively little or no digestive power. The food will, therefore, pass from the stomach, not in the form of a fine emulsion, like chyme, but with undigested lumps in it, and these, irritating the intestine, will be not unlikely to produce diarrhoea; moreover, the intestine itself may also suffer by extension of the inflammatory condition, from the stomach along the mucous membrane. Then we notice, in addition to the sickness and nausea, those symptoms to which the term of biliousness is applied. The person is dull, heavy, and languid, disinclined to exertion, mental or bodily, irritable, or peevish, the complexion is muddy, and the conjunctiva is slightly yellowish, and perhaps there is more or less severe headache. All of these point to disturbance of the functions of the liver; but the explanation of the different factors of biliousness must be reserved for the succeeding lecture.

NOTES FROM A CLINICAL LECTURE ON SOME OF THE DIAGNOSTIC DIFFERENCES BETWEEN BRONCHITIS AND HEART-DISEASE.

Delivered at Guy's Hospital.

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ALTHOUGH the clinical features of bronchitis and heart-disease are sufficiently distinctive to be at once recognised by the experienced medical man, apart from a physical examination of the chest, and although the *post mortem* appearances in the two diseases are also markedly different, yet it is not at once apparent why, when both show congestion of the lungs, as the main symptom or immediate cause of death, they should present such distinctive peculiarities. It is important not only to recognise these differences, but to set clearly before ourselves their causes; since, in complicated cases, this will lead to a correct diagnosis, and suggest the appropriate treatment. In a simple case of severe bronchitis, the patient is seen sitting up in bed, and breathing with difficulty; that is, he is using all the muscular effort he can to draw air into the chest, having, indeed, true dyspnoea. At the same time his face is blue, and his extremities livid. The chest is resonant on percussion, the abdomen is not enlarged, and there is no dropsy. In the heart case, notably when the mitral valve is diseased, the patient has not dyspnoea, but apnoea; he can easily fill his chest with air, but, owing to the impeded and irregular circulation, he experiences the distress known as cardiac apnoea or breathlessness. His skin may be pale or yellow at the upper part of the body; the chest may be dull at its lower part, especially on the right side; the abdomen may be full, the liver