Lectures.

FORCE PRODUCTION.

A LECTURE AT THE HARVARD MEDICAL SCHOOL.¹

BY PROF. H. P. BOWDITCH, M. D.

THE blood has been said to have the following five functions: (a.) To convey from the alimentary canal to the various organs and tissues of the body the materials whose decomposition furnishes the force manifested there. (b.) To distribute from the lungs the oxygen necessary for the complete using up of the force-producing material, and for oxidizing the products of decomposition of the tissues. (c.) To convey material for building up the tissues. (Nutrition in its narrowest sense.) (d.) To convey the products of decomposition of the tissues and fluids of the body to the organs destined to excrete them. (e.) To distribute and regulate the heat in various parts of the body. The consideration of these five functions, and of the organs associated with them, includes the whole of physiology so far as it relates to the life of the individual. We have already followed the course of food through the processes of mastication and deglutition into the alimentary canal; have studied the action of saliva, gastric juice, pancreatic juice, and bile; have seen how part of the material is absorbed into the circulation by means of the lacteals and blood-vessels, and now, next in order, I will call your attention to the production of force in its various forms, and to the materials which furnish that force. Owing to the unsatisfactory condition of organic chemistry it is impossible to follow the food through its various stages of retrograde metamorphosis within the body, and to trace the corresponding liberation of energy. We must, therefore, be content to study (1) the ingesta, (2) the products of decomposition which are excreted, and (3) the forces which are set free as a result of this decomposition. By varying the conditions under which this force production occurs we can reach certain conclusions with reference to the nature of the process.

Referring briefly to a former lecture you will remember that food is divided into two main classes, nitrogenous and non-nitrogenous. Non-nitrogenous food is further divided into fats and starches. Now the first question is how are the products of decomposition of these different articles of food excreted? The earliest experiments on this point are those of Bidder and Schmidt. They analyzed the urine and the feces, and, from the amount of nitrogen present, estimated the amount of nitrogenous material decomposed in the body. They also, from an examination of the CO₂ excreted in the expired air, estimated the amount of non-nitrogenous decomposition. They based their calculations upon Liebig's theory that in the urine and feces all the nitrogen of the food is excreted. Bischoff and some other observers, however, subsequently denied this, maintaining that so far from finding all the nitrogen which goes in with the food coming out with the feces and urine, there is a large deficit, sometimes amounting to thirty per cent., and that from these excretions alone the amount of nitrogenous material decomposed in the body can not be determined, because gaseous nitrogen may be excreted in the lungs and also from the skin. In investigations of this sort it is very difficult to arrive at absolutely correct results, for errors

may creep in in the analysis of the food. It is difficult to find food which will be eaten with a relish (and to study the normal action there must be a relish), which can be subjected to accurate elementary analysis. In the second place, errors are likely to occur in collecting the excreta, especially where the animals used as subjects are kept in cages, and their urine collected as it flows out of the cage in jars, for under these circumstances a certain loss by decomposition is likely to take place. Various expedients have been resorted to to avoid these errors, such as training dogs to pass their urine at command, or drawing it by the catheter. In an elaborate series of experiments Professor Voit, of Munich, has demonstrated very clearly that when the investigation is made with all the necessary precautions this nitrogen deficit does not exist. This was the result of experiments on men, dogs, horses, birds, and silkworms, these last being employed for the sake of extending the observations over as wide a range of animals as possible. It is only fair to say, however, that Seegen, of Vienna, has reopened the question, and has thrown doubt upon some of Voit's conclusions, leaving the matter still unsettled, though most physiologists accept Voit's results as satisfactory. The nitrogen of the feces exists, of course, chiefly in the form of albuminoid material which has not been digested, but it is none the less important to take it into account in striking a balance between the ingesta and egesta. According to Professor Voit this decomposition of albuminoid materials into urea takes place partly in the tissues themselves and partly in the blood and lymph circulating around and through the tissues. The first part, which forms a constituent portion of the body, he calls organized albumen, while to that which is contained in a liquid form in the blood and lymph he gives the name of circulating albumen. Organized albumen resists decomposition very firmly, but circulating albumen is undergoing constant decomposition. That albumen exists in the body in two states, differing from each other in their stability, is an undoubted fact, and Professor Voit's theory has to this extent a sure foundation, but in regard to the place and manner of decomposition the theory is to be regarded merely as an exceedingly probable hypothesis.

As to the effects produced by feeding an animal with different kinds and amounts of food, experiment has shown that when a dog is supplied with just enough nitrogenous food to keep him in good condition the amount of nitrogen excreted in the feces and urine just equals the amount given in the food, and conversely when the amount of nitrogen in the feces and urine is equal to that of the food the condition of the animal is said to be one of nitrogen equilibrium. If a dog is fed a certain amount of albumen, and excretes an equal amount, he receives just the amount which is needed, but if more albumen is fed nitrogen is stored up in the tissues for future needs, while if less is fed the animal gradually starves, excreting nitrogen to the last. A few figures in regard to a merely hypothetical case may serve to make this point clearer. Suppose a starving dog excretes an amount of nitrogen corresponding to fifty grammes of nitrogenous food. If, now, this dog receives fifty grammes of nitrogenous food a day he will be found to excrete, not fifty, but seventy grammes, that is, there is a deficit of twenty grammes a day, and the animal is slowly starving. Now give him seventy grammes of nitrogenous food a day, and instead of his excretion remaining constant he excretes eighty

¹ Reported by W. D. Bidwell. Revised by Professor Bowditch.

grammes, that is, there is still a deficit of ten grammes, and he is still starving, but more slowly than at first. Now feed him eighty grammes, and he excretes eighty-five. Finally, if he receives eighty-five grammes daily the excretion remains the same, that is, he gets enough nitrogen for his needs, and has reached the nitrogen equilibrium. If he receives more than this amount of nitrogenous food, say ninety grammes, he at first excretes but eighty-five grammes, the balance being stored up in the tissues, but if the same amount of ninety grammes be fed for several days his excretions of nitrogen will gradually increase to that limit. In other words the nitrogen equilibrium may be reached at various points, the lowest being that at which the supply is just sufficient to balance the daily loss. On the other hand, if the animal be fed on non-nitrogenous food the amount of nitrogen excreted at first is nearly equal to that excreted when the supply and need balanced, but rapidly decreases till it reaches a tolerably constant excretion, representing the destruction of organized albumen. Here it should be stated that when more nitrogen is taken in than the minimum necessary to keep the body in nitrogen equilibrium, the effect of the surplus is to put the body in better condition for performing work. Knowing, then, the chemical composition of fresh meat, dry albumen, etc., we find that 3.4 grammes of nitrogen is equivalent to 100 grammes of fresh meat; also that 15.6 grammes of nitrogen is equivalent to 100 grammes of dry albumen. This amount of dry albumen will contain, besides the nitrogen, hydrogen, and oxygen, 50 grammes of carbon. Besides the amount of carbon that comes out in CO_2 from the lungs a certain amount is excreted in the urea, twenty per cent. of which is carbon, so that having examined the nitrogen excretion, and determined the amount of albuminoid material which must have been decomposed to furnish it, and having made the proper allowance for the carbon contained in this albuminoid material, we can say that any amount of carbon which appears in the urea or in expired air over and above that corresponding to the albumen must be derived from non-nitrogenous food. Now, having determined the amount of nitrogen excreted in the urine and fæces, and the carbon excreted in the urea and from the lungs, we know that a certain amount of nitrogenous and non-nitrogenous decomposition has taken place. In other words, we have a test by which we can determine the amount and kind of organized material undergoing decomposition in the body in a given time.

What causes this decomposition, this retrograde metamorphosis? When physiological chemistry was in its infancy, in the days of Lavoisier, it was supposed that it was due to the presence of inspired oxygen, but very soon it was found that the mere presence of oxygen was not sufficient to cause such a change, that though oxygen must be present to enable the final products of decomposition to be excreted, still it might be present and no change take place. The real cause is as yet unknown, but must be sought for in connection with the living protoplasm with which the organic substances of the food are brought in contact. It is well known that many chemical compounds, the constituents of which have only a feeble affinity for each other, may be broken up by dialysis or filtration. Alum, for instance, is a substance which is composed of elements whose chemical union is so slight, and which differ in rapidity of filtration to such a degree, that it may be broken up into an acid and a base by filtering. It is

not improbable that the living tissues through which the products of digestion diffuse may play a similar part in initiating decompositions.

Let us next consider the food ingested with reference to the energy to be liberated by its decomposition. This gives rise to several problems. In the first place, the object of taking food may be to provide the body with materials to set free mechanical force, that is, to get as much muscular strength as possible; or, in the second place, it may be to enable the body to produce as much heat as possible; or, thirdly, the problem may be to increase glandular activity, to stimulate the secretion of milk in nursing women, for example; fourthly, it may be desired to restore or to build up the tissues, as in convalescence from an exhausting disease; or, fifthly, to build up and strengthen the nervous system, and enable it to act with ability and promptness. Thus there is a variety of problems depending on the kind of force wanted. It will be noted that only in the first two classes is any energy set free from the body. In these two the condition of affairs outside the body of the individual may be directly altered. In the other three the results are confined wholly to the body and within the body. We will now proceed to take these up in order, and we will begin with that form of energy known as motion or mechanical work.

Original Articles.

A CASE OF COMPLETE INVERSION OF THE UTERUS,¹ TREATED BY THE MODERN METHOD, WITH RULES FOR CARRYING OUT THE PROCEDURE.

BY CLIFTON E. WING, M. D., BOSTON.

SOME time ago² I reported to this Society a case of inversion of the uterus of fourteen months' duration successfully replaced by the "continued gentle pressure" plan of treatment, without the use of anaesthetics, and without pain to the patient. The following case, treated by the same simple means and with equal success, will serve as another example of the advantages of this method.

The case was seen in consultation with Dr. Moulton, of Lawrence, Mass.

The patient was a primipara, aged nineteen. Of the confinement the doctor writes me as follows: "Mrs. —'s labor commenced about twelve o'clock on the night of December 7th, and was completed December 8th, about eight o'clock P. M. It was, to all appearances, a natural instrumental delivery, that is, nothing occurred different from usual in forcep cases. We (Dr. Dana was present in consultation) waited fifteen or twenty minutes, and then made slight traction upon the cord. The placenta came without any particular assistance, as usual, but immediately after it occurred complete inversion of the uterus. There was great flooding. The placenta was somewhat attached to the inverted fundus, but was easily removed. I pushed the protruded uterus back into the vagina at once, but did not feel justified in doing anything further at the time on account of the patient's exhausted condition, for she became pulseless and we feared immediate death; but, under brandy,

¹ Read before the Section for Clinical Medicine, Pathology, and Hygiene of the Suffolk District Medical Society, February 14, 1883.

² November 29, 1879.