An Address ON THE LARGE INTESTINE AND ITS WORK.

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It is not long since such a subject as that I have selected would have appeared barren—indeed, offering little more than the descriptive detail available to the anatomist or the brief summary of the clinician content with endeavouring and often succeeding in making a correct diagnosis and then relying upon traditional experience and knowledge for treatment. Having, however, had the privilege of seeing and observing the progress of surgery during the last thirty years, and having met with many difficulties in the successful treatment of disease by operative measures, I was prompted to make an attempt to seek out the cause of some of these difficulties.

After the publication of the discovery by Pasteur of the biological nature of fermentation, and after the application by Lord Lister of that knowledge to the treatment of diseased processes, young men with new ideas naturally came to occupy the stage. These men, who were fascinated by the new doctrine—namely, that disease could be and was caused by an invasion of the body by a living organism—began to apply the new doctrine indiscriminately. Both Lord Lister and Pasteur preached that, though invasion is possible, the further development of the invader does not take place unless there be the requisite food and other suitable conditions present. It was, however, not long before it was forgotten, or appeared to be forgotten, that it was the human body itself that was at fault, and that the fluids of the body presented not only food of proper composition, but also that they were under conditions suitable for the success of an invasion. We have in our defensive resources, the antiseptic or aseptic method or a combination of the two, means whereby we endeavour—and, it can hardly be denied, with great success—to prevent invasion. But, should invasion occur in spite of our vigilance and care, there are at our disposal subtle organic substances the administration of which, we sincerely hope, will some day be attended with great and lasting success; such are the antibodies, serums, and vaccines of many kinds.

While your preventive measures may be perfect, and you may be cocksure of your serum or vaccine, yet these will avail you little if the body is not clean in a physiological sense, for if not clean it contains material favourable to the growth of one or other of those small enemies of ours which are ever ready to seize upon suitable food, enemies which, if not present in our internal tissues, exist as normal inhabitants of all our coverings, internal and external—the mucous membranes and the skin. It behoves us, therefore, not only to adopt measures against invasion, but also to do away with all that renders our bodies unclean, and to remove the substances which are not natural to us, so allowing their places to be taken by tissues and juices of normal or standard composition, and infertile, from lack of suitable food for the growth of our enemies unless in overwhelming numbers or attacking points rendered vulnerable by serious injury.

The great problem, then, is, how can we maintain our bodies in a state of physiological cleanliness? Well, the complex machinery of the bodies of men and beasts depends primarily for its smooth and efficient working upon the fuel consumed and upon the due and proper expulsion of all refuse. This refuse is naturally divided into two portions: (1) That which comes from an individual organ or part of the complex machine; and (2) that which is common to the whole. I desire to-day to draw your attention only to the refuse that is common to the body as a whole, and to show, if possible, what, if any, advantages accrue from the changes that arise in that refuse during its transit along that portion of the alimentary canal modified into the large intestine, to point

out the conditions essential for the due progress of the faeces along the canal, and, lastly, to allude to a simple, sure sign of delay in transit.

THE LARGE INTESTINE.

The enlarged terminal portion of the gut acquires greater and greater importance in the progressive changes in size and form seen in the vertebrate series until man is reached. It will, therefore, not be uninteresting to trace the different steps in the evolution of the large intestine, because collectively, if not in individually, the various changes that arise therein show that in each a purpose exists if we are but fortunate enough to discover it.

The first indication of the formation of a differentiated large intestine may be seen in the tortoise, for example, *Chylone mydas*. In this animal the last few inches of the intestinal tract are dilated to form a simple, elongated, ovoid reservoir for the reception of the intestinal refuse, and from it is an opening direct into the cloaca and thence

Fig. 1.—*Chylone mydas*. Two-thirds natural size.

In *Python spilotes* there is not merely a dilatation; there now comes into existence a recess directed backwards, that is, in a direction contrary to the outward flow of faeces; this constitutes the most primitive form of caecum met with. In examples from earlier forms there is no other change apparent than the enlargement of the lumen without undue thinning or any other obvious change in the wall. In the *Python* there is, then, a recess into which some of the contents of the intestine as they are driven onwards into the terminal portion find their way either through the establishment of an eddy or by definite and reverse muscular action. From these two initial forms we may easily follow the evolution of the large intestine. If we suppose this distended and terminal piece of gut to be proportionately lengthened we can obtain the 5 to 6 ft. found in man, and if we likewise increase the recess we may obtain the large caecum of the common rabbit.

Fig. 2.—*Python spilotes*. Natural size.

A statement of the characteristics of the colon is, however, incomplete without mention of the sacculations which, in the higher mammals, form its most striking feature. If we take as our first illustration of the large intestine that of the *Aard wolf*, it will be observed that there is dilatation of the first part only, the recess forming the caput caecum—coli with a thin but uniform muscular wall. This ends in a long terminal portion with a very well-developed longitudinal muscular coat similar in appearance to that of the human rectum. Here, then,

is a colon divisible into two portions—(a) short and distended part with a thin uniform wall, and (b) long and less distended portion with a thick muscular wall. Again, in *Hyrax capensis* there is, with one exception, a similar arrangement, for here the thin or first portion of the external wall has its muscular fibres grouped into three bands instead of being uniformly distributed over the

wall, with the result that in between the bands the thinner portions are apt to, and do actually, bulge to form sacculations. Here, then, we have the beginnings of the colon as it is seen in man—a distended and sacculated first portion, and a less distended and uniformly coated second portion. In man, however, the first portion is by far the longer, the second the shorter, forming about a sixth of the whole.

A brief reference must here be made to the vermiform appendix, which, performing but little useful function, frequently gets into mischief. The appendix, which is the representative of the terminal portion of the simple or complicated caecum, plays, indeed, a definite rôle, and so long as it continues to play its part—small or great, we hear nothing of it. In the rabbit, it will be remembered, a spiral valve directs the movement of the contents through the

caecum, but in man they just pass into its lumen and back again with great regularity. To ensure this, the human appendix, though small in size, retains a well-developed muscular wall (circular and longitudinal) which is capable of contracting and relaxing in obedience to ordinary stimuli, and, further, is capable of acting in two

Fig. 4. - *Phascolomys latifrons*. Half natural size.

and opposite directions—towards the free end and back again to the caput caeci—coli.

The Faecal Refuse in the Large Intestine.

The first portion from its enlargement is especially designed for delaying the onward and outward flow of the intestinal contents, and in consequence the rate of flow of the contents of the ileum rapidly diminishes as soon as the ileo-caecal valve is passed. This is in accordance with the condition which obtains when a stream passing through a narrow tube suddenly emerges into a wider one—the

greater the disparity in width the greater the decrease in the rate of flow. The recess—the caput—allows of a back flow with eddies more or less pronounced according to the degree of fluidity of the contents and the force with which the stream enters.

The shape and size of the caput suffices, then, to induce a reduction in the rate of flow and to give rise to

Fig. 5. - *Hyrax capensis*. Half natural size.

eddies so as to favour thorough mixing. But, in addition to the formation of a large lumen and a recess, it is found that the external muscular coat of the gut, instead of remaining of uniform thickness and covering the entire extent of the wall, in many of the higher mammals—especially in the vegetable and mixed-food eaters—disposes itself into three distinct bands, wide or narrow, with definite intervals. Further, these bands appear to be, and actually are, of shorter length than the gut itself, acting in much the same mechanical way as a “gather” in a garment. Moreover, the greater the distension of the lumen the shorter, relatively speaking, these bands appear to become. The practical result of this special disposition of the external muscle coat in the caput and the first portion of the large intestine is to induce a movement which continues the work set up by the establishment of eddies; that is, it gives rise to a churning of the contents and thus keeps going the mixing process automatically started as the refuse passes from the small into the large intestine.

The large intestine, then, by its modification becomes mechanically fitted to allow (1) of slowing of the onward stream of the intestinal contents, (2) of starting a mixing process by the formation of eddies (due simply to the passage from a narrow to a wider tube), and (3) of churning the contents so as to obtain a thorough mixture.

The mixing of the faecal contents appears to be essential, and, though it takes place especially in the caecum, yet it may, and does, occur in the entire length in which the peculiar triple-band disposition of the external muscular layer is found. While this churning is taking place another important process occurs—namely, the rapid absorption of water, the greater part of 70 per cent. of the total being absorbed during transit through the large intestine. Consequently the mixing and drying of the contents go on simultaneously in the first portion of the large intestine.

As the contents become drier the result of the special movement is to induce the formation of the faeces into roundish masses of the size natural to the capacity of the gut beyond, and of the form and shape in which, under natural conditions, the refuse of the body is expelled.

Thus in the first portion of the large intestine the contents of the ileum accumulate, undergo a thorough mixing and churning, lose the greater portion of their water, and then become moulded into the shape and size suitable for the very last piece of the gut, which merely drives its contents onward as occasion requires.

The Chemical Changes in the Refuse during its Transit.

Although very little is known regarding the various, normal and abnormal, fermentative changes that occur

and of the specific chemical substances which result from such processes, we do possess indirect evidence that some substance or substances are formed and absorbed into the system with beneficial effects. When the refuse dries up to the natural standard in a given person, and there is no irregularity in the performance of the act of defaecation, health is at its highest standard, and associated with this is the feeling that "a man is at his best." When, however, the contents become too dry and the expulsion is delayed beyond the natural time, the first degree, as it were, of constipation comes to exist—a condition accompanied by heaviness, with inability to collect one's thoughts, with headache and irritability of temper, and with want of concentrative power to perform mental or bodily work.

If I may be permitted to digress into the realm of agriculture, I would like to point out that in show (cattle) animals, which are kept up to the highest standard of "bloom," as it is technically termed, the consistency of the faeces and the regularity of their expulsion are kept almost without variation. There are few men who really understand this and who can regulate it to a nicety; and it is not unusual to find that high-priced bulls, on changing hands at a sale, not infrequently suffer from lack of this particular kind of knowledge and judgement in their next attendant. Such animals commonly enough die from "stoppage," which kills them with greater ease and rapidity than is the case with man.

What is derived from the contents of the large intestine that produces this "bloom" in animals or the feeling of good health and good spirits, etc., in man? What is the nature of the substance or substances that are absorbed in minute quantities? A rich field for inquiry awaits any eager and persevering student of this subject. All we can now say is that there is evidence that we obtain some material of importance to our bodies from the refuse as it passes along the colon, and so long as the quantity absorbed is small a pleasant feeling of enjoyment in life results, whilst if it increases beyond a definite but unknown limit unpleasant consequences are apt to manifest themselves.

The mechanical uses of the modifications in capacity, in form, and in muscular disposition seen in the human colon are, then, clearly of two kinds. The *one* is for ensuring a thorough mixing and churning of the contents by to-and-fro movement to make delay effective, and the *other* is for retaining the formed, moulded, and harmless faeces and for expelling it at convenient times.

The object of the mixing is to induce and promote a new digestive process, bacterial or otherwise, so as to abstract from the refuse something which is of a stimulating nature and which gives "bloom" to the show animal and a feeling of being "in the best of health and spirits" to the man.

This process occurs especially, if not entirely, in that portion of the large intestine which extends from the caecum to near the end of the sigmoid. The greatest activity is seen in the caecum, less in the ascending colon, and still less beyond, so that the contents, after reaching the sigmoid and while in the rectum, undergo little, if any, change.

The Mechanism for the Transit of Faeces along the Large Intestine.

We have seen how the large intestine is modified to serve certain purposes, and that definite as well as ill-understood processes occur in its contents; it now remains to show the mechanism whereby the contents, with or without deleterious substances, are conveyed along their natural course from the moment they enter this channel. We know where the power lies, the nature of the material to be conveyed, and the composition and source of the lubricant necessary for transit. When the contents are fluid lubrication is superfluous, but as the drying process occurs so does the increase in the formation of a lubricant become necessary, and the dryer the refuse the greater the amount of lubrication required. The ease with which the onward progress of the faeces takes place, then, depends upon three factors: (1) The strength of the muscular wall and accessory power of the abdominal walls; (2) the fluidity of the contents; and (3) the amount and quality of the lubricant. The power in the wall of the gut is derived solely from the central or subsidiary nervous system, and the amount transmitted to this portion

of the gut depends directly upon the total amount available and upon the portion of that total left unconsumed by the exercise of the will. For example, if the will insists on the brain working until all the energy available is consumed there will be none left to supply the muscular wall of the large intestine; or if the nerve energy be consumed in excessive exercise or work, again there will be none left. Further, the effect produced by the contraction of the muscular wall depends upon the size of the lumen and the friction between the contents and the lining of the gut. Now the larger the lumen, say from too great an accumulation, the less effective will be the contraction of the muscle; and the less the degree of lubrication the greater must be the friction; consequently, the less the proportionate result induced by the contraction of the muscle of the wall when the gut is overdistended and the contents too dry.

The lubricant of the large intestine is mucus, which is secreted by the mucous cells of the tubular glands lining the mucous membrane. There is no lubricant, either natural or artificial, that exceeds mucus of normal composition in effectiveness. Whenever the contents of the large intestine are fluid or semifluid the necessity, as I have already said, for the secretion of mucus of normal composition does not arise, but as the faecal contents dry it is essential that the secretion of mucus be increased, otherwise the resistance between the dried contents and the wall rapidly augments and eventually becomes so great that no amount of muscular force exerted by the gut will effect any appreciable change in the position of the contents, and "stoppage" results. The amount of mucus secreted, therefore, should vary directly with the degree of dryness of the faecal contents, but there is no power known which automatically stimulates the secretion of the mucus when it is required. So far as can be judged, the secretion of mucus depends upon other factors, and the chief of these is the maintenance of a normal composition of the blood and lymph circulating through the wall of the gut in which the mucus-secreting glands lie.

The due progress of the contents of the large intestine is, we know, essential to health, and any alteration in the rate of transit or in the digestive processes gives an indication as to whether the tissues of the body are supplied with the food they require, whether they get rid of all the waste material due to work, and whether the natural repair for their proper maintenance takes place. Any interference, however induced, with this progress necessarily disturbs not only the colon itself, but also the remainder of the body, for the refuse common to the entire body passing along, being delayed in transit, is especially liable to undergo further changes, which end in the production of absorbable and deleterious substances of unknown composition. Such substances, however subtle their composition, are known rather by the effect they produce than by any chemical reaction or physical properties they may possess. Some of them have been identified; most have not. This opens up the very extensive and important field spoken of as "auto-intoxication," to which I shall not now refer.

The consequences of slight retardation in transit, simple constipation, with its associated disturbances, are familiar to all of you. Although we cannot be quite sure, we think and believe we are correct when we say that the symptoms are due solely to the absorption of some subtle product or products of a particular form of fermentation or chemical disintegration which is liable to take place in the faecal contents whose transit is thus delayed. There is, I venture to think, one sure sign of this condition. It is the enlargement of the tongue until it becomes too large for the mouth, and so takes upon itself the impress of the teeth.

THE TONGUE AS AN INDICATOR OF EXCESSIVE FLUID IN THE TISSUES OF THE BODY.

The tongue, as you know, is an organ which is peculiarly constructed. Its mass is made up of bundles of muscle fibres some of which are arranged in vertical, longitudinal planes with other fibres passing from side to side through or between them. Consequently the bundles of muscles cross one another, and in order to give each of them complete freedom of movement independent of its neighbour, the material intervening between the different sets of bundles and holding them together is very delicate

areolar tissue in which are large lymph spaces. An organ of this structure lends itself to great variations in size according to the amount of fluid in the lymph spaces between the bundles of muscle fibres. This is exemplified in acute inflammation or oedema of the tongue—say, after a sting from a wasp in a person susceptible to the poison of that insect. Once the structural nature of the substance of the tongue is comprehended, it is easy to understand what follows.

A tongue which is indented by the teeth is obviously one that is too large for the mouth, and if enlargement be only temporary it will be one in which the lymph spaces in the intermuscular areolar tissues are filled and even distended with fluid containing the waste products of the surrounding tissues, if not of others derived from various organs and tissues of the body. This state of the tongue is, to my mind, an indication, not of any peculiar local condition in this organ, but of a similar condition throughout the body wherever the tissues, from their physical structure, will allow of the accumulation of fluid—lymph of normal composition or one charged with deleterious substances. Accordingly the indented oedematous tongue tells first of all that there is an excess of fluid in the tissues of the body, and my own clinical experience shows that this excess of fluid is most commonly associated with undue delay in the transit of refuse along, and retention of faeces in, the large intestine—coprostasis. Delay in the expulsion of formed and moulded faeces, even if it extends to a period of many days, is not in many persons attended with any ill effects, and this is doubtless within the experience of all of you. This fluid in excess is, we may be quite sure, not mere normal lymph, but lymph charged with subtle chemical substances which probably vary a great deal in their composition. When this accumulation of faeces—coprostasis—comes to exist, the first sign of that physiological uncleanliness I have spoken of shows itself. I am convinced that this condition of excessive fluid in the lymph spaces of the body is a most potent, but not of course the only, factor in making disease possible in any given individual, and the most powerful in controlling the results of one and all surgical operations. Therefore the conditions which may and do arise in consequence of irregularities of many kinds in the transit of the common refuse of the body, chiefly along the first portion of the large intestine, are very numerous and of great importance to the physician and surgeon.

CONCLUSIONS.

The interest taken in the colon and its functions during the last few years has been very great. In 1901 Dr. Barclay-Smith put forward a suggestion that in consequence of the advance in the preparation of food, rendering it digestible, nothing now remains for the colon to do, and that it may be regarded as a useless appendage to our bodies. Sir Arbuthnot Lane goes further, and characterizes it as a cesspool, presumably either to be cleansed at periodic and stated intervals, as our sanitary cesspools are to-day in some old-fashioned places, or to be altogether done away with, as in the modern method of sanitation. Metchnikoff regards it as having developed in order to act as a reservoir, so that primitive man might run after his prey or away from his pursuing enemies without undergoing the risk of stopping or slowing his rate of progress to evacuate his intestine. Professor Keith, without expressing any decided opinion for or against the above hypothesis, wonders whether we cannot restore to the colon its former function. He appears to suggest that ingenuity might yet be exercised with advantage in the direction of finding an agreeable dietary which will give back its old work to this large tract of the alimentary canal, and that unless something useful be done the colon will certainly come to be regarded under our present civilization as an incumbrance to man in the performance of his daily work.

In conclusion I would say the work of the colon, apart from its use as a storage and expellor of the common refuse, is, so far as I have been able to discover, (1) to dry the contents as they leave the small intestine, and (2) to get some useful substance out of the refuse while it is mixed and churned and undergoing fermentation with, it may be, disintegration. This substance, though as yet of unknown quality, gives to the body that which it

requires for the development of that feeling which is best described as being "in the best of health and spirits"; further, it is something of all-important value to the individual. Excess of it is deleterious; lack of it is attended with pronounced changes in general nutrition, and perhaps progressive inanition, leading after a variable time to death from simple loss of vigour and strength.

ON HEALTH, FATIGUE, AND REPOSE.

BEING EXTRACTS FROM THE LADY PRIESTLEY MEMORIAL
LECTURE DELIVERED BEFORE THE NATIONAL
HEALTH SOCIETY.

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LORD BEACONSFIELD in one of his many luminous utterances declared that the great social question which should engage the attention of statesmen is the health of the people. The health of the people is the wealth of the nation, and Huxley, in one of his letters to John Morley, wrote that "The great thing to work for, as time goes on, is vigour as one lives," that is to say, "health," which is just another way of saying "fitness" for the duties that lie before us. With Sir Philip Sidney we may say: "The ingredients of health and long life are great temperance, open air, easy labour, little care."

In health the machinery does not chafe in the working—all goes on silently, smoothly, and without noise, while there is complete adaptation to the environment. The one part of the body cannot say to the other, I have no need of thee. Organs, however insignificant they may seem, may prove to be of paramount importance in the economy, as has been proved by the recent discoveries regarding the functions of such little-known and apparently unimportant organs as the pituitary body, the pineal, thyroid, and thymus glands, not to mention others whose functions and history we are just beginning to discover.

Most of the breakdowns in a man's life, however, are due to the driver himself, either because of ignorance or recklessness, or both. "We do those things we ought not to do, and we leave undone the things which we ought to have done," and then we wonder "that there is no health in us."

Our forefathers used the word "health," wholth or whole-ness, to indicate soundness not only of their bodies, but also of their implements and utensils used for hunting, for cooking, and for weapons of war and the chase. The highest perfection is a "sound mind in a sound body." "Life without health is a burden, with health it is joy and gladness."

Fatigue is the result of over-action, and above all sustained and continuous action of an organism as a whole, or of one or more of its organs. Not only is the over-worked organ itself affected, but owing to the chemical or metabolic changes underlying all sustained strenuous endeavour and action—without sufficient periods of rest or repose—other organs and parts of the body are speedily implicated. In fact, as pointed out by F. S. Lee, fatigue is a universal biologic phenomenon, while the activity of living substance tends to inhibit or restrain its further activity.

MUSCULAR FATIGUE.

In muscular fatigue the chemical reserves upon which our movements depend are gradually used up; the greater the effort the greater the metabolism and consequent expenditure. In addition, however, poisonous by-products, more especially carbonic acid and lactic acid and acid potassium phosphate, are formed. These products are not removed with sufficient rapidity, and remain to clog the machine, and indeed act as toxins. These fatigue products not only poison the organ in which they are formed, but they pass into the blood and are conveyed by it to other parts of the body, and poison them also, before they are destroyed or excreted.

The study of fatigue, therefore, is largely a study of chemical metabolism. When the muscles are in action normally their activity depends in part on the supply of