is the consequence, and not the cause, of the arrest of evolution. Tumour tissues are imperfect, and remain imperfect, and work cannot be expected of such. Their differentiation has been arrested before they were capable of work. Tumour tissues never work because, with the rarest possible exceptions, they never reach the perfection of maturity. The exception proves the rule; a few mammary adenomata attain such a high degree of perfection that secretion has been known to take place in certain portions of them. The vast majority falls far short of this.

THE ARREST OF DEVELOPMENT OF ORGANS.

If it is asked what could interfere with the power of hereditary transmission to such an extent as to cause the arrest of the differentiation of the tissues in one part of the body and the formation of one kind of tumour, or the arrest of their involution in another and the formation of another kind, I can only point to the analogy of the arrest of development of organs, and say that I can see no reason why such a power may not fail from mere exhaustion, as for instance in old age, either of organs or of individuals, when it is notorious that the liability to tumour growth becomes greater and greater, or from excessive action, as when an enormous number of young cells is produced with great rapidity in response to some persistent chronic irritation. Whether the action, or want of action, of any organ in the body could have a similar influence over the power of hereditary transmission and bring its work to a sudden stop it is impossible to say. There is one structure in the body at least that appears to be capable of abrogating the laws that control the growth of tissues and of enabling them to increase in size without limit; but we know too little of these things as yet. The study of physiology is of yesterday. At our best we have only a very general acquaintance with some of the most conspicuous individual actions of what may be called the gross mechanical apparatus of the body. We know next to nothing of the essential organs of life, those that really matter where growth and development are concerned. We are only just beginning to grasp the fact that many absolutely insignificant-looking structures, some of them almost microscopic in size, possess the most extraordinary power over growth, and even over life itself; and we are only just beginning to realize that no organ or tissue in the body exists for itself alone, but only in relation with every other organ and tissue. It may be that when we know more about these things some structure will be found which has some control over hereditary transmission and the development of tissues as distinguished from their growth. Until then—and it must be admitted the prospect is not a good one—all our hopes of finding such a thing as a cure for the growth of tumours (for amputation, though it may free the patient from the consequences, can in no sense be regarded as a cure) must rest either upon finding some remedy which, like Coley's fluid, can directly kill the tumour cells without endangering too greatly the vitality of the normal tissues, or upon stimulating to increased energy the normal tissues that surround the tumour until they are able to treat those degenerate cells that have failed to attain their full development and have continued to grow at the expense of the organism without being of any service to it, in the same way that the workers treat the drones.

DR. EDGAR BATES has examined all the children in the Dee and Washington schools of Ogden, Utah; 890 pupils were tested with the illiterate card, and 184 were found to be suffering from eyestrain. Of these 134, or 73 per cent., had headaches; 114 complained of symptoms originating in close work, and 57 of them stated that words became blurred; 34 had blepharitis. A gradual increase of cases was noted from the kindergarten up to the highest forms. Many of the pupils stated that their symptoms were first noted after an attack of measles or scarlet fever. Some of the children who complained of eyestrain were wearing glasses, but they had been fitted by an optician without the use of a mydriatic, which Dr. Bates considers futile; most ophthalmologists will subscribe to this opinion. In reading this paper, which appears in *Ophthalmology* for January, 1912, it is necessary to remember that eyestrain is far more frequent in America than it is here, and also that leading questions as regards headache were put to the children.

THE FUNCTIONAL NATURE OF THE CAECUM AND APPENDIX.*

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EVERY year the opinion gains ground that the great bowel, from appendix to rectum, has become, so far as man is concerned, a useless and dangerous structure. Exactly ten years ago (October, 1902) Dr. Barclay Smith[1] of Cambridge gave a clear expression of this new conception.

"If there is any truth," he wrote, "in the suggestions offered in this paper, they have an important practical application as regards the large intestine of man. From the nature of his diet a reliance on extrinsic digestive aid as is furnished by bacteria is no longer a physiological necessity. The statement is perhaps a bold one, but I am convinced that the large intestine is practically a useless encumbrance to him."

In the following year (1903) appeared Metchnikoff's famous book on *The Nature of Man*.[2] In that work (p. 69) the new conception receives a more decisive statement:

It is no longer rash to say that not only the rudimentary appendix and the caecum, but the whole of the large intestine are superfluous, and that their removal would be attended with happy results.

Before either of these statements had been made, Mr. Arbuthnot Lane[3] had reached the conclusion that the human caecum and ascending colon served, in a certain class of cases described by him, as a "cesspool," and put his new conception into practice either by excluding the great intestine from the digestive tract by "short-circuiting," or, at a later date, by its complete excision. The result of his operations shows (1) that life is possible without a great intestine; (2) that in certain cases the conditions of life are improved. It is very apparent that Mr. Lane's pioneer operative measures are finding every year an increasingly wide application, and that the views of Metchnikoff and of Barclay Smith are gaining in acceptation amongst medical men.

THEORIES REGARDING THE USES OF THE CAECUM AND COLON.

If these statements are well founded—if the great bowel is as useless and injurious as is said—then medical men are face to face with a condition which threatens the health and survival of modern civilized races. Before assigning so large a part of man's digestive tract to the list of his useless structures, it will be well to inquire what we know regarding the function of the great bowel as a whole, and the uses of its parts in the various members of the animal kingdom. Such an inquiry brings home to us that our knowledge of the function and significance of the great bowel is vague and unsatisfactory. We do not know, in any animal whatsoever, the exact function or functions of the great bowel; so far we have only guessed at them.

The subject is one which engaged the attention of John Hunter; in his collection there are many specimens which illustrate the structure of the various parts of the great bowel in all classes of vertebrates, but unfortunately he left only the briefest record of the conclusions he had formed regarding their uses. "If we could understand," he wrote, "the use of the ileo-caecal valve, then we should understand the uses of the caecum."[4] He observed that there was a material difference between the contents of the ileum and of the caecum; the contents of the caecum and colon underwent putrefactive changes, and in his opinion the ileo-caecal value was to prevent the putrid contents of the caecum from regurgitating within the ileum. In a case of gun-shot wound of the abdomen he observed that the colic contents had passed upwards in the ileum, a result which he supposed might be due either to a lesion of the nerve supply of the bowel or to a reversed action of the intestine. In the light of our modern knowledge it is interesting to note he had observed that the colic contents were not putrid at birth nor did the caecum of the newly-born contain gas. He was also familiar with the fact that the caecum was small, the colon short, and

* Abstract of a demonstration at the College.

the faeces of thin consistency in carnivora and allied animals, while the opposite was the case in vegetable feeding animals. Further, he recognized that animals with a perfect gastric digestion, such as ruminants, had comparatively small caeca, while in others, like the horse, with an imperfect gastric digestion, the caeca were large. He therefore recognized, a very important fact, that there could be an interchange of function between stomach and caecum. The task of describing and interpreting Hunter's specimens fell to Sir Richard Owen. The conclusion he drew from an examination of the series of specimens which illustrate the anatomy of the ileo-caecal region of the bowel was:

> Comparative anatomy concurs with the results of undesigned experiments, as in cases where artificial openings have been established in the human intestinal canal, in showing that a change to gastric digestion is repeated upon the food in the caecum; chemistry has also shown that the chyme here again becomes acidified, after having been neutralized by bile in the small intestine.[5]

Both Hunter and Owen recognized that the process of digestion underwent a sudden and decided change at the ileo-caecal orifice, but neither the one nor the other suspected that the digestive process was the result of a putrefactive action. That discovery, of course, belongs to modern times.

Reference has already been made to a paper[1] which Dr. Barclay Smith published ten years ago, one which has not received the attention its importance deserves. The theory formulated there has the merit of seeking to explain the anatomy of the ileo-caecal region. His theory is based on the justifiable assumption that all the digestive changes of food within the great bowel are due, not to any digestive secretion, but to the action of bacteria which find a permanent abode in the caecum and colon. He inferred—an inference which has been justified by the observations of Dr. Hertz[6]—that the antiperistaltic movements which Dr. Cannon[7] had seen to occur in the colon of the cat also occurred in the upper part of the human colon, and that the purpose of the ileo-caecal valve was to prevent the contents of the caecum and colon, which were undergoing bacterial digestion, from being forced by the antiperistaltic movements within the ileum, where a totally different digestion was in progress. So far as I know, this was the first satisfactory explanation offered for the presence of an ileo-caecal valve. Dr. Barclay Smith looked on the rich distribution of lymphoid tissue in the ileo-caecal region as stations furnished to protect the body from invasion by the bacterial hosts employed in the purposes of caecal digestion. He made the further assumption, which may or may not be warrantable, that our modern diet needs no bacterial action for its full digestion and assimilation, and that therefore the great intestine is a useless and injurious structure in the economy of modern man. Excision, however, is not the only remedy. There is an option; in place of appealing to surgery to adapt our digestive tract to our present dietary, it seems possible that we may discover a diet which is suited to our present digestive tract. Before we can do that, we must know something of the normal processes of digestion which proceed within the great bowel, not only of man and of animals allied to him, but of vertebrate animals generally.

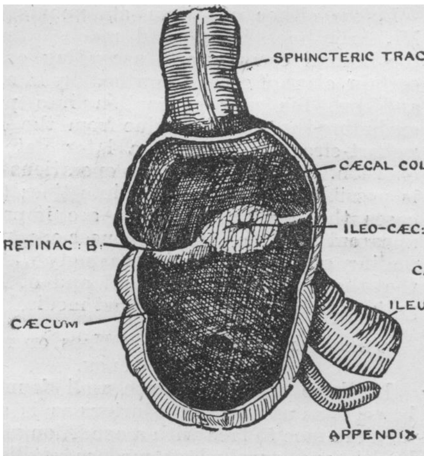

Fig. 1.—The human caecum laid open to show the ileo-caecal orifice, the retinacular bands, the caecal colon, and caeco-colic sphincteric tract. One-third natural size.

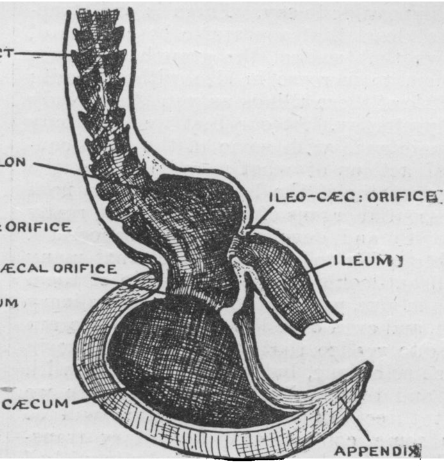

Fig. 2.—The caecum of the rat (twice natural size) laid open to show the same parts as are seen in Fig. 1.

ILEO-CAECAL SPHINCTER.

John Hunter, with his usual prescience, realized that a knowledge of the ileo-caecal valve would provide a clue to the nature of the caecum. In 1903, as a result of a series of observations on all classes of vertebrate animals, I came to the conclusion that there was always a functional muscular sphincter at the junction of the small intestine with the great.[8] It is present in the amphibian bowel, the reptilian, avian, and mammalian. When the great bowel undergoes retrogression, as it has done in bears and in their allies and in many forms of insectivora and edentates,[9] the ileo-caecal sphincter is the only visible structure which remains to mark the junction of the small intestine with the large. My observations led me to regard the ileo-caecal sphincter as a constant structure, its main function being to serve as a mechanism for regulating the passage of the contents of the ileum into the caecum, in much the same way as the pyloric sphincter regulates the passage of the food from the stomach into the duodenum.

Independently, Dr. T. R. Elliott[10] had observed the ileo-colic sphincter in action, and placed our knowledge of it on a much sounder basis. In May, 1904, he was able to announce that stimulation of the sympathetic nerves of the inferior mesenteric plexus causes it to contract, and at the same time the same stimulus brings about an inhibition of the neighbouring musculature of the ileum and colon; adrenalin, he found, had a similar effect. Dr. Barclay Smith and he[11] concluded that the strength of the sphincter was commensurate with the thickness of the muscular coat of the caecum and adjacent part of the colon, and that its purpose or function was to prevent the caecal contents being forced backwards into the ileum under the pressure caused by antiperistaltic movements. Sir William Macewen,[12] unaware of the observations made by Dr. Elliott or by myself, announced in the Huxley Lecture of 1904 that he had recognized the presence of an ileo-caecal sphincter and studied its action in a soldier who had a temporary window in the wall of his caecum. In this manner a most important step forwards was made in our knowledge of the caecum; we came to see that there is an elaborate neuro-muscular mechanism which regulates the passage of chyme into the caecum and prevents the regurgitation of the contents of the caecum into the ileum. The significance of the ileo-caecal orifice and sphincter is clear if we admit that they mark a point in the alimentary tract where one form of digestion ends and another begins.

FUNCTIONAL DIVISIONS OF THE CAECUM.

In my preliminary studies[8] of the ileo-caecal region of the bowel, I came to the conclusion that in the fully developed mammalian caecum, such as that of the rabbit or rat, there are three parts which appear to be demarcated for functional purposes (see Fig. 2). These three parts are:

1. The caecal colon, which lies above or beyond the ileo-caecal orifice; it is usually regarded as the commencement of the ascending colon, but a comparative study shows that it represents the primitive caecum of the lower vertebrates (Fig. 2).

2. The caecum proper, which lies below or proximal to the ileo-caecal orifice, and arises as a diverticulum from the caecal colon.

3. The apical or appendicular part, which is characterized by its narrow lumen and its thicker walls. Professor Berry[13] showed twelve years ago that it is lined by a mucous membrane laden with lymphoid tissue.

The same three divisions are to be recognized in the human ileo-caecal region—caecal colon, caecum and appendix (see Fig 1). In the rat's caecum there is a distinct sphincteric ring (caecal sphincter) at the junction of the caecum and caecal colon. In the human caecum this sphinteric ring (caecal sphincter) is permanently united with the ileo-caecal orifice, and forms the well-known retinacular bands (Fig. 1). The action of the caecal sphincter can be studied in the rat (see Fig. 3). At one minute (Fig. 3, A) the ileo-caecal orifice is closed and the caecal sphincter dilated; at another this sphincter is in action (Fig. 3, B), and the ileum opens directly into the caecum; other states are represented in Fig. 3, C, D. As yet we know nothing of the action of the retinacula of the human caecum, but from what we know of their action in other animals we may safely infer that during caecal digestion they can regulate the passage of the colic and iliac contents to and from the caecum.

CAECO-COLIC SPHINCTERIC TRACT.

In mammals which have the caecum well developed, the first part of the colon—corresponding to the commencement of the ascending colon in man—is differentiated from the caecum below and the rest of the colon above by the degree to which its circular musculature is contracted (see Figs. 1 and 2). I regard this part as serving as a functional sphincter of the caecal colon. It is true that not one of the many experts who have watched the passage of a bismuth-laden diet have been able to verify the existence of this sphincteric tract. It must be remembered that it is hard to be certain of the movements in the ileo-caecal region; the bony pelvis prevents us from having a clear image, and the ascending colon always bends downwards in front of the caeco-colic junction, so that it is difficult to watch the passage of bismuth-laden chyme as it passes into the beginning of the colon. In the routine of abdominal operations the functional differentiation of the segments of the bowel is not observed owing to the paralytic effect of anaesthetics; in the routine of the *post-mortem* room the functional states are not seen because the putrefactive action of the caecal and colic contents soon destroys the vital action of the muscular coat of the great bowel. The three reasons which convince me I am right in differentiating a functional sphincteric tract are:

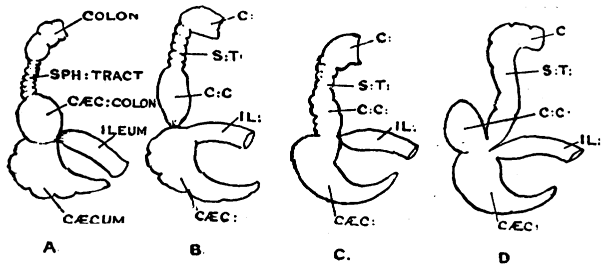

Fig. 3.—Figures illustrating four functional states of the ileo-caecal region of the bowel of rats. In A and C the ileo-caecal sphincter is closed; in B and D it is relaxed. In A and B the sphincteric tract is closed; in C and D it is open. Various conditions of the caeco-colic sphincter are shown in A, B, C, and D.

1. Its presence in all mammals with well-developed caeca. Comparative anatomists have failed to recognize it because in some animals, such as the horse, the caecal colon has become highly specialized and elongated, thus thrusting the sphincteric tract some distance away from the ileo-caecal orifice.

2. In young and healthy subjects, if formalin be injected by the arterial system, before putrefaction has destroyed the vitality of the musculature of the bowel, this tract will be seen (see Fig. 1 and also Professor Symington's drawing in *Quain's Anatomy*, vol. iii, Part IV, p. 190, 1896).

3. It is impossible to decompress gas from the caecum of the living; the caecum always contains gas; that is a necessary correlative of the process of digestion going on within it. The gas is locked up in the caecum just as it is in the cardiac part of the stomach; it cannot be pressed into the ileum because of the ileo-caecal sphincter; it cannot be pressed along the ascending colon because of the sphincteric nature of the muscular wall at the commencement of the ascending colon.

THE ILEO-COLIC REGION OF BIRDS.

The ileo-colic region reaches its highest specialization in graminivorous and vegetable feeding birds. A study of the avian mechanism helps us very materially to understand the working of the ileo-caecal tract in mammals. In Fig. 4 I have represented the termination of the ileum and beginning of the colon of a young ostrich. Between the ileum and colon there is a well-demarcated chamber corresponding to the caecal colon of mammals. It is separated from the ileum by a sphincter (ileo-colic), and from the colon by a caeco-colic sphincteric tract (Fig. 4). The two long caeca open from the caecal colon by a common orifice, which is guarded by a strong caecal sphincter. It is easy to see that the caecal colon is the feeder of the caeca; when it contracts, its contents, being shut off by the sphincters at its iliac and colic ends, are forced into the caeca or onwards into the colon.

It appears, however, that the caecal colon has also a selective function. In the valuable report[14] by the committee which recently inquired into grouse disease—Dr. Hammond Smith drew my attention to this source of information—a number of valuable observations are recorded. The rough fibres and débris of heather shoots and of moor fruit present in the chyme when it reaches the colic caecum are passed on to the colon through the sphincteric tract, while the more fluid matter is pressed into the caecum. Thus, the caeca, which together are twice the length of the small bowel in the grouse, are filled with fluid, alkaline chyme from the ileum; in the caeca its reaction becomes acid, probably from the bacterial digestive processes which take place in the caeca. The caeca are only partially and occasionally emptied, the caecal contents differing completely in character from the usual "droppings" of the grouse. Here, then, in its highest form we find the caecal colon acting as a selective mechanism and the caeca set aside as separate chambers for a special and apparently bacterial process of digestion and absorption.

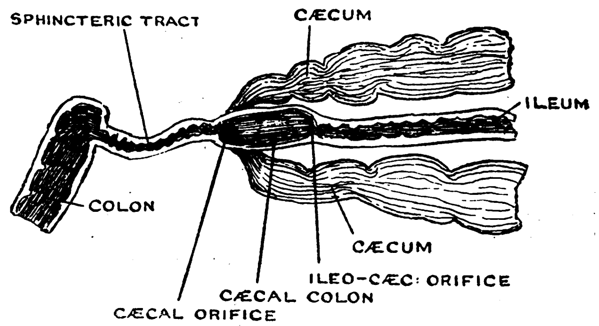

Fig. 4.—The ileo-caecal region of a young ostrich.

EMPTYING OF THE CAECUM.

In rodents the caecum begins to pass into action as soon as food enters the stomach, but at no time does the caecum of any animal become completely emptied. It is well known that in animals which die of starvation the caecum and adjacent part of the ascending colon retain their normal contents, but the significance of this fact has not received the attention its importance merits. If the digestive processes undergone by food in the caecum and great bowel are due to bacterial action, then it is absolutely necessary that a caecal "batch" must be preserved to secure the continuation of bacterial digestion. Observations made by Elliott and Barclay Smith have an important bearing on the mechanism which secures the retention of the caecal batch. In carnivores, such as the cat, ferret, dog, stimulation of the sacral visceral nerves causes a constriction and emptying of the great gut from the caecum to the rectum. In vegetable-eating animals the effect extends to only the distal part of the colon; the proximal part of the colon—corresponding to the caecum, ascending colon, and the hepatic part of the transverse colon of man—are outside the influence of this emptying mechanism. Holzknecht and Dr. A. E.

Barclay[15] have observed the peculiar expulsory movements in the splenic part of the transverse colon. We know that expulsory movements occur in the colon at and distal to the splenic flexure. We must infer that the preservation of part of the caecal and colic contents is essential for the digestive economy of vegetable-feeding mammals, and if we admit that the digestive processes of the caecum and colon result from the action of certain bacteria we see why Nature has placed the proximal part of the colon outside the influence of the expulsory mechanism. In the proximal part of the colon antiperistaltic or retaining movements are observed, never the movements of complete expulsion. For the same reason we can explain the absence of the great bowel in all forms of fishes; the differentiation of the bowel into small and great intestine appears with the evolution of land-living, air-breathing vertebrates. A bacterial form of digestion, necessarily attended by the production of gas within the bowel, would upset the stability of gill-breathing, free-swimming forms. The digestive juices of fishes are notoriously strong. From the point of view of comparative anatomy, we must regard the great bowel as a part which has been elaborately modified and evolved, through the course of long ages, for a highly peculiar form of digestion.

Some years ago I noted the following facts relating to the digestive changes in the bowel of rats fed on oats. In the jejunum free starch was abundant; in the lower part of the ileum no starch reaction was obtained. It was not until the contents of the colon had reached the mid part of the transverse colon that the starch reaction became again manifest. These observations seem to indicate that cellulose digestion had proceeded in the proximal part of the colon, exposing fresh granules of starch which were absorbed in the middle and distal part of the colon.

THE ALLEGED VESTIGIAL NATURE OF THE APPENDIX.

For many years the appendix vermiformis has been regarded as one of the vestigial structures of man's body, an opinion which has prejudiced us against any real endeavour to discover its nature and function. Twelve years ago Professor R. J. A. Berry, on the evidence he then produced, came to the conclusion that the appendix should be regarded as a specialized part—not a retrograde part—of the caecum, and that is the conclusion which every one must reach who makes an impartial survey of our knowledge of the comparative anatomy and of the evolution of the human ileo-caecal region. At least in three separate orders of mammals the apical part of the caecum has become specialized and demarcated from the rest of the caecum in the form of an appendix. It has never been suggested that the appendix of the koala, wombat, rabbit, lemur, or of the anthropoid apes is a vestigial structure. So like are the caeca and appendix of the gorilla and chimpanzee to the same structures in man, that I know of no character by which an expert could tell the one from the other. In the anthropoids, as in man, the caecum and appendix undergo the same peculiar changes in passing from infancy to adult age. We know from their fossil remains that the great anthropoids are of extreme geological antiquity; were their appendices injurious or vestigial structures, there has been ample time to accomplish its complete suppression. Kelly and Hurdon, in their well-known work,[16] cite the small calibre of the appendix as evidence of its retrograde character; it is more in keeping with what we know of animal structures to regard the smallness of calibre as an adaptation to a peculiar but unknown function. We do not suppose the oesophagus to be a retrograde organ because it is narrow as compared to the stomach; we fortunately know the function of the gullet.

PROBABLE CAUSE OF DERANGEMENT.

Every one who is acquainted with the more recent developments of our knowledge of the surgery and pathology of the abdomen agrees that, in a large proportion of civilized men and women, the great bowel—especially the caecum and appendix—is abnormally liable to derangement and to disease, but as to the cause of that condition there is a diversity of opinion. No observations of recent years throw more light on appendicitis than those which Dr. Weinberg[17] made on chimpanzees dying in captivity. We have seen that the caecum and appendix have the same form in the chimpanzee as in man. In ten out of sixty-one chimpanzees appendicitis was found at death. We have no reason to suppose that in its natural habitat this anthropoid is specially liable to appendicitis—the evidence is purely negative; but as soon as the chimpanzee comes into captivity, and is placed on a human diet and exposed to human contagion, it becomes subject to a prevalent human disease. In the chimpanzee's case we blame the diet. Metchnikoff and Dr. Barclay Smith, as far as man is concerned, regard the appendix as at fault. When we think of how the diet of highly civilized races has changed—in quality, quantity, and character—in comparatively recent times, one must marvel that our organization, which was evolved to deal with a more primitive and more precarious supply of food, has accommodated itself to modern conditions so well as it has. We know that beyond the neolithic period, when cereals began to be cultivated, some six thousand years ago, there lies a vast hinterland of rude human existence, when man must have lived on the natural products of the country. With the discovery of fire and of the artificial preparation of food (we know that man had discovered the use of fire before the end of the Pleistocene period) the task of the alimentary system must have been greatly altered. The greatest changes, however, are those of more recent centuries—the concentrated nature of food, its plentiful supply, its highly artificial character. When we come to realize how slowly evolutionary processes have affected man's body in past times, we can hardly expect our internal digestive system to adapt itself to the rapid pace demanded by the ever-accumulating resources of civilization. The modern changes we see at work in our teeth and jaws have set in since neolithic times; we have every reason to suppose these are allied to, and contemporaneous with, changes affecting the whole alimentary system.

Thus an impartial survey of the evidence at present at the disposal of the anatomists indicates very plainly that we cannot hope to prevent or cure the ailments to which the great bowel is liable so long as we regard it as a hopelessly injurious or useless structure. On the other hand, if we regard it as having all the anatomical appearances of a useful structure, our outlook becomes hopeful if we can only discover what its uses are. If we only knew how to keep it suitably and profitably employed by altering our diet to meet its requirements, it will, we have every reason to think, serve us and future generations just as well as it answered the digestive needs of primitive and successful races in the past.

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WITH the approval of King Edward's Hospital Fund for London and the Charity Commissioners, an amalgamation of the British Lying-in Hospital with the Home for Mothers and Babies, Woolwich, the President of which is H.R.H. Princess Christian, has been provisionally arranged under the title of the British Hospital for Mothers and Babies. The subtitle of the latter institution, "National Training School for District Midwives," will be retained, and the joint hospital will occupy a new building, which is shortly to be erected at Woolwich for the purpose. The authorities of the British Lying-in Hospital have been led to this step by the rebuilding and alteration in character of the district around Endell Street, which has greatly reduced the number of its patients, whilst the addition of maternity wards to most of the large hospitals has also influenced their decision. They feel that the usefulness of the institution will be materially increased if it follows the population to the outskirts of London.