period in which he had the opportunity of seeing the organs *in situ*, are conclusive. In his book⁴ he describes how the ileum in its junction with the colon becomes kinked, and the passage of faeces through it is impeded. In this way the stasis starting in the colon extends to the small intestine.

These observations made at the operating table were subsequently confirmed *in vivo* by means of the X rays by Gottwald Schwarz,⁵ who observed that in constipated subjects the faecal matters remained in the lower part of the ileum almost eight hours, and that the movements of the large bowel, although increased, are irregular and inconstant in direction, so that the faeces are pushed up and down for some time. This is the cause of the drying up of the faeces in constipation, the intestine exerting an action similar to that of a shaking apparatus.

All these observations confirm the assertion that constipation is due to the intestinal flora which causes the retention of the faeces in the large bowel for a long time. These undergo putrefaction. Hence the production of the soluble poisons on the one hand, and the extraction of the poisons retained by the dead microbes on the other give rise to auto-intoxication. All these phenomena are removed by the removal of the large intestine. Therefore there is no doubt that the seat of constipation is in the large bowel, and that the intoxication occurring in a constipated person is the result of the activity of the microbes of the intestine.

THE ILEO-CÆCAL VALVE.

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SOME 20 years ago Cantani in Naples and others very strongly advocated the so-called enterocolysis for the treatment of certain intestinal disturbances, some of which had their seat in the small intestine. Bearing in mind the old French denomination of the ileo-cæcal valve as the "barrière des apothicaires," I desired to ascertain positively whether the supposition of olden times, that an enema could not pass that valve, was right, or whether it was possible that, as Cantani asserted, medicated liquids could by a simple enema be introduced into the lower part of the ileum or small intestine. This problem led me to a series of researches,¹ the results of which were confirmed by different anatomists (Toldt, Zuckerkandl, and others).

It cannot be a matter of indifference to the economy of metabolism whether, if I may be permitted the metaphor, the small intestine be closed towards the large intestine by a Chinese wall with an outlet, or whether between the two exists the policy of the open door. It is remarkable that 300 years after the discovery of the ileo-cæcal valve such contradictory suggestions as to its function and action are to be found in literature.

Although the historical part of the question is very interesting and shows how far advanced in detail was the knowledge of the old anatomists, Varolius, Bauhin, Van Tulp, Fallopius, Fabricius d'Aquapendente, and others, I refrain from entering upon too minute a quotation. However, I cannot help quoting a passage from an anatomical lecture by Archangelus Piccolomini, printed in 1586,² in which the question of the competency of the valve is so well made out that there is really little to be added. It runs as follows:—

Valvae tres, quemadmodum in corde, ad caecum intestinum sunt additae, tanquam ostiola quaedam deorsum spectantes, hunc in finem, ut materiam in intestinis gracilioribus conclusam deorsum illabi sinant, illapsam autem in crassiora impendant, ne sursum resilire possit. Proinde harum valvularum inventu, quicquam in crassioribus intestinis, sive stercus sive putridus flatus exsistit, prohibetur, ne in violentis abdominis compressionibus in tenuiora nobilioraque intestina possit refundi ad praepediendas nobiliores naturae functiones. Has autem valvas caeco additas observatione deprehendes, si colon inferne impleveris aqua, illudque sublime suspensum teneas, cernes nihil prorsus aquae valvas illas perfluere et in graciliora intestina subire. Sed quid de aqua dico? cum si rectum intestinum aëre ac flatu, qui longe aqua est penetrabilior, sufflando impleveris, ne minimum quidem flatus erumpere videbis a colo et caeco in ileum, tam arcte claudunt valvae illae. Imo, si pugno premas colon, potius

aliquid disrumpetur, quam valvae illae cedant flatus ascensui in graciliora intestina.³

Other literature to similar purport is quoted in my publications before referred to.

The most difficult thing in making these anatomical preparations is to get the material unaltered and without tearing it. Unfortunately, these parts of the bowels are to be obtained only *in the course* of post-mortem examinations, when those who assist the operator are apt to pull upon the intestines and thus destroy the natural conditions. This of course renders them useless, and it cannot be pointed out too strongly that the caecum and the adjoining part of the ileum must be cut out most carefully immediately after the opening of the abdominal wall, before any other manipulation takes place. After the resection of about 8 inches of the colon (see Fig. 1) this gut is closed by means of a ligature. The ileum is not ligatured. If, then, with a double bulb syringe air is insufflated from the ileum into the colon—that is, in a direction opposite to that in which the insufflation was carried out by Piccolomini—it will be found that this air does not escape in the most diverse degrees of fullness of the gut, even though the ileum be not ligatured. This means that the valve closes quite tightly in a passive way.

After having carefully removed fat and mesenteric elements and looking at the front of such a preparation (Fig. 1), the peculiar disposition of the anterior tænia is striking; it describes an arch with its concavity opening upwards and inwards, corresponding to the inclination of the axis of the caecum towards the colon. In this part of the gut there are constantly found three haustra which I have called *haustrum caecale*, *haustrum ileo-colicum*, and *haustrum coli primum*, following the direction from below upwards.

In the intestine represented in Fig. 1 it appears that the *haustrum ileo-colicum* is covered by the two neighbouring haustra to such an extent that only a small triangle of it is visible, the base of which is formed by the tænia, the apex looking towards the ileum. *This configuration is to be seen in all bowels with a competent valve.* Looking at the back of the gut the peculiar direction of the tænia also strikes one. It rises perpendicularly from the region where the ileum enters the caecum. At this very spot I found a band of longitudinal muscle fibres, from 0.08–0.16 inch in length, diverging from the tænia and forming a small bridge passing behind the ileum and over the two adjacent haustra. I have found this band regularly in all guts examined and have called it *habenula caeci*. Toldt⁴ misapprehended its nature. We shall still have to deal with it. By removing fat and blood-vessels from the sulcus under this bridge it is possible to pass a probe under the latter (Fig. 2).

In order to ascertain how a competent valve would appear when seen from the inside I introduced and fastened by a ligature a sort of window in the wall of the gut on the side opposite to the valve so as to be able to inspect it. This method has since proved satisfactory for the purpose of demonstration. (Zuckerkandl in his Topographical Atlas and others have copied it.) Fig. 3 shows the view of such a valve as seen through the above-mentioned window. The ileo-cæcal valve represents, according to its shape, an invagination of the end of the small intestine into that part of the bowels where the large intestine begins a sort of duplication, which bulges into the cavity of the caecum. Its opening forms a button-hole-like fissure, produced by the apposition of two falciform folds. The upper fold is very long, similar to a real plica sigmoidea. Its ends are called *frena Morgagni*; the lower one is much the shorter, semicircular,

³ Three valves, as is the case in the heart, are appended to the caecum, like little doors looking downwards, in order that they may allow matter confined in the smaller intestine to pass downwards, but prevent that which has passed into the greater (bowel) from returning upwards. Therefore, by the intervention of these valves whatever, whether faeces or putrid gases, may be in the larger intestine, is prevented from being forced back during violent compression of the abdomen into the smaller intestine to the hindrance of the higher functions of nature. But in order to observe these valves attached to the caecum, if you fill the colon from below with water and hold it suspended on high, you will see that none of the water flows backwards through the valves. But why do I speak of water? when if you fill the rectal intestine by insufflation with air and flatus, which is far more penetrating than water, not even one jot of flatus will you observe to escape from the colon and caecum into the ileum, so tightly do those valves close. On the contrary, if you squeeze the colon with your hand something will break, rather than those valves will yield passage for the ascent of flatus into the small intestine.

⁴ Toldt: Die Formbildung des Menschlichen Blinddarmes und der Valvula Coli. Sitzungsberichte der Kaiserl. Akademie der Wissenschaften, 1894, Band ciii., heft 1.

⁴ The Kink of the Ileum in Chronic Intestinal Stasis.

⁵ Zur Physiologie und Pathologie der Dickdarmbewegung, Münchener Medizinische Wochenschrift, 1911.

¹ Oscar Kraus: Langenbeck's Archiv, 44, 2; Wiener Klinische Wochenschrift, 1902.

² Anatomiae Praelectiones, xi.

FIG. 1.

Gut with competent valve seen from the front. H.A.CÆ.,
Haustrum caecale. H.I.C., Haustrum ileo-colicum. H.C.P.,
Haustrum coli primum.

FIG. 2.

Gut with competent valve seen from behind. A probe under
the habenula cæci.

FIG. 3.

Competent valve seen through a glass window

FIG. 5.

Microscopical section through both lips of the valve.
U, Upper lip. L, Lower lip. E, Epithelium. L, Lymphoid
follicles. M, Muscle fibres. B, Connective tissue.

FIG. 4.

Incompetent valve.

FIG. 6.

Scheme of a competent valve.

FIG. 7.

Scheme of an incompetent valve.

but as long as the opening of the valve. According to Luschka, the lips of the valve consist of the mucous membrane and of the circular fibres of the muscularis. Further, according to his statement, the serosa does not participate in the invagination, and also the longitudinal fibres of the small intestine do not enter the substance of the valve, but getting thicker, pass over into the wall of the large intestine. According to Toldt,⁵ however, both the longitudinal fibres of the tænia and those of the ileum reach the *edge* of the lip of the valve. My histological researches confirm Toldt's statement. The microscopical preparation clearly shows that the longitudinal fibres reach the edge of the valve (Fig. 5).

As can be seen from the diagram, the ileo-cæcal valve is a real valve, which allows the passing over of the contents towards the large intestine, but prevents passage in the opposite direction. It closes perfectly passively, even in the anatomical preparation—that is to say, without muscular action. It may be compared with Bunsen's indiarubber valve, a "lip-valve," as used in chemical laboratories. It consists merely of a small closed indiarubber tube, forming the outlet of the glass tube through which the gas passes. A very small longitudinal cut or slit is made with a sharp razor into the rubber, which consequently permits the gas to escape. To a recurrent gas stream, however, the lips of the slit will be compressed and will close still tighter.

What occurs if we continue to force air into the gut without heeding the tension of the bowel? That which Piccolomini describes—namely, "ut aliquid disrumpetur." We find that: 1. The colon tends to stretch straight, the curve or bending of the cæcum having partly disappeared, a condition shown by the straighter direction of the anterior tænia. 2. In this forced stretching the shortest, that is the inside, tænia has been ruptured. 3. The haustrum ileo-colicum now lies quite free and is no longer covered by the haustrum cæcale and haustrum coli primum. 4. On the posterior aspect we see that the upper insertion of the habenula has been torn off, the habenula itself having retired downwards. 5. The connective tissue forming the normal adhesions between the anterior part of the upper wall of the invagination between ileum and colon have been torn over an area of the size of a halfpenny. 6. By accurate measurements I have been able to demonstrate that the upper lip had thus been shortened and retracted from the lower one, that the invagination had disappeared at the point in question, and that the valve is no longer competent (Fig. 4). Its lips are gaping, as can be seen through the window inserted in the bowel. *I must especially emphasise that all these, and only these, changes take place regularly, as often as the insufflation passes a certain limit.*

The sketches of Figs. 6 and 7 demonstrate the mechanism whereby the valve closes.

In competent valves the fibres pull with equal force from all sides unto the base of the funnel with a force greater in proportion to the extent to which the bowel was inflated. The adhesions between cæcum and ileum resist this pulling so long as the lips of the valve remain united. If, on the other hand, the valve is torn, the force of the insufflation works (as shown by the arrows in Fig. 7) straight on the upper border of the lip, pulling it away from the lower lip, and the valve is no longer competent. Now, in my opinion, which is also shared by Toldt,⁶ it is the very habenula which protects the adhesions between ileum and cæcum from being torn.

Among the bowels examined by me I have found 12 the valves of which were not competent. I am quite aware that the material used in my investigation, some 150 cases, is not very extensive; but it is very difficult to get complete unlacerated guts from the post-mortem room. Anyhow, according to my findings the competency of the valve must be considered a normal condition so long as control investigations fail to prove the contrary.

The bowels with *incompetent* valve showed the following particulars: (1) colon and cæcum were very wide in all of them; (2) the colon was quite straightened (straight anterior tænia); (3) the three haustra lay in apposition, the haustrum ileo-colicum not covered by its neighbours. Very often no sharp limit existed between the three haustra.

⁵ Ibid.

⁶ Besides that, the mesenteric covering helps, by tight fibres which retain the curve of the cæcum *in situ*, to keep the valve competent.

Thus we find in bowels with insufficient valvulæ coli the same changes as in incompetency artificially produced.

In new-born children the valve is incompetent, and we must surmise that competency is attained in the first years of life. In the post-mortem on a boy 5 years of age I found the valve competent. Whether in the cases of incompetency quoted we have to deal with a persisting infantile condition or with acquired incompetency I cannot say.

These are the anatomical results of my investigations which I may be permitted to sum up in the following conclusions.

1. In a gut removed from the cadaver the valve shuts up gas-tight by passive action. That is the normal condition.
2. It is possible to destroy the competency of the valve by excessive insufflation of the colon. The changes which are thus produced are typical.

Until now we have dealt with the conditions of the valve in a gut removed from the cadaver, and we have seen that under merely mechanical conditions the valve is competent and closes gas-tight in a passive manner. But we were only speaking of the way the valve closes. Logically we have now to ask: How does the valve open? Does this occur in a merely passive manner—that is, exclusively by the inner pressure of the contents? Unfortunately, we cannot get an answer to this question except by inspection, for this could only be seen *intra vitam*. Moreover, experiments on animals fail to help us to resolve this question, for in most animals used in experimentation, although they possess more or less distinct thickening of the circular muscle fibres, we fail to find a really competent valve, not only in the highest anthropomorphs, but even in new-born babes. And there is not only a great morphological but also a functional difference between a simple ring-muscle and a complete and competent valvular apparatus. The first stands open and may contract, as the other circular fibres of the gut do, while the intestinal valve of the adult man closes perfectly by passive means. These reinforced circular fibres are to be seen in the guts of dogs, where the rudiment of a valve scarcely projects into the lumen of the bowel. In the intestines of the dog the part corresponding to the human ileum passes directly over into the colon, and the relatively large cæcum forms a special appendage. In murines (mouse, field-mouse), in rabbits and hares, and so on, the condition is similar. In most of these herbivora the cæcum is large; in the hare about ten times as big as the stomach. Although they do not shut there exist sometimes two valves between the cæcum and colon, but none between the small and the large intestine.

It has already been mentioned that *intra vitam* we have to deal not merely with mechanical but with bio-mechanical conditions, in which not only the turgor of the intestinal wall and the tonus of the muscles participate—conditions which must have a still better influence on the tight closing of the valve—but in which the innervation also has to be taken into consideration. V. Zessl has shown that the sphincter vesicæ opens not merely in a passive way, following the pressure of the detrusor, but actively also by irritation of the nervi erigentes, and even after the detrusor has been cut through. V. Frankl-Hochwart and Froehlich succeeded in relaxing the sphincter ani by cortical irritation. Taking these statements into consideration, we may suppose by analogy that this shutting or closing apparatus, also consisting of circular and longitudinal muscles, might be opened by nervous action; that it probably is opened in consequence of the contact with the chyme, or, to use a technical term, reflexly on short circuit, though it generally closes quite mechanically in the same way as the bladder and anus do.

Of course, this refers only to physiological conditions. For it will not do, as Hyrtl has done, to take the vomiting of fæces which occurs in ileus as a proof of the normal competency of the valve. Ileus is certainly not a physiological condition, and any physician who has had the opportunity of observing a case of ileus will surely admit that the organism is struggling against the obstacle with an amount of strength surely sufficient to produce all the changes that I have described above.

But, as has been mentioned, it is only possible to draw these conclusions by analogy, for we are not able to ascertain the facts by experiment on animals. We know, however, of a simple observation which is as demonstrative as an experiment would be. This is the classical case communicated by Nothnagel in 1884, in his well-known contributions to the

physiology and pathology of the bowels. In one of his patients ileus had been protracted during nine days. Some hours before death a very small quantity—if I remember correctly 8 oz.—of a coloured NaCl solution had been injected per anum, and it was possible to detect the coloured liquid about 15 inches above Bauhin's valve. This experiment shows quite distinctly that antiperistaltic movement can arise under pathological conditions.

How can we utilise this experiment to solve the question of competency. In a double way. In his case Nothnagel had to deal either with a valve that had been originally incompetent, or with one that had become incompetent in the course of the ileus.

Chance plays a great part in medicine. I remember that when preparing the fresh anatomical specimens for a demonstration before the Society of Internal Medicine in Vienna, as chance would have it, the first valve I came on was incompetent; yet they are by no means frequent as that might seem to suggest. So it is quite possible that Nothnagel's valve also was originally incompetent. But further, Nothnagel relates in a most illustrative way the treatment that had been applied before his arrival—enemas of iced soda-water, Hegar's injection of two quarts of liquid, and so on. Taking into consideration that the whole colon can scarcely take a little over two quarts on an average, we cannot be surprised if the valve was torn by such proceedings, especially by hyper-extension.

I am very sorry that since my first paper appeared this quite harmless, but very illuminating, experiment of Nothnagel has not been repeated. I am sorry that it has not been repeated in invalids without ileus, that it has not been repeated in patients with intestinal fistula, and that the changes as described by me have not been observed. By so doing one would surely have succeeded not only in throwing light on this subject but also in getting indications as to the limits of insufflation that physiological conditions will allow.

Different authors have tried to bring into connexion the function of the ileo-cæcal valve with the movements of the bowels. Anyone who has devoted himself to the study of peristalsis will surely admit that this is a very difficult problem, and I must confess I am not brave enough to get into a scrape unnecessarily; and I do not see any necessity for it, for the closing of the valve has but a very loose connexion with the intestinal movement.

There has been much discussion concerning the purpose and utility of the valve and as to what were the aim and idea of its action. Several authors have asserted that scientifically we are not entitled to claim a special utility for any organ and consequently not for the ileo-cæcal valve. But this view cannot stand a serious discussion. Even Darwinism deals with teleology: the great doctrine of adaptation, mimicry, and other phenomena are nothing else in principle than teleological. But concerning the law of adaptation it is stated that "the function creates the organ." Seeing by phylogenetic as well as by ontogenetic studies that there is a steady transition from the tube with open communication between small and large intestine to the complicated apparatus of an entirely competent valve, we must say that the existence of this organ is entirely due to the fact that its function has been established by degrees and *vice versa*: if the valve does exist it must consequently have got a function—that is, a purpose. In common language these two words are used for the same thing.

But as far as my opinion goes it will be not the anatomists but the chemists who will tell us what is the purpose of the ileo-cæcal valve. Anyhow, I find, to my thinking, a striking proof of the normal competency of the valve in the intestinal chemism. It is commonly known that of late years a long series of so-called "fistula analyses" has been carried out, and this by most reliable authors, such as Ewald, Nencki, Zakowski, and others. Anyone who has at any time been occupied with anatomical research on the gut knows of the penetrating smell of the products of decomposition of the albuminoids, an odour which will cling to anything, the hands, clothes, or instruments. But none of these authors could find in the small intestine appreciable quantities of these products of decomposition—viz., phenol, scatol, indol, mercaptan, and so on. I can only explain this by the fact that the valve is competent as regards the passage of gas, though only in so far as normal conditions are dealt with, for we know well that

in pathological forms of digestion, especially in anomalies of acidity in the stomach and of the secretion of bile, putrefaction (decomposition of albuminoids) can take place in the small intestine. But that has, as stated, nothing to do with normal physiological conditions.

Up to date nothing has been discovered concerning the possibility of opening the intact valve through its innervation. Histological conditions do not permit us to exclude this possibility, but the physiological statements, as made for other sphincter muscles, allow us to assume it as probable. It is not probable that the intact valve can be opened from the large intestine; and the old quotation from Piccolomini still holds good: "Klyster penetrare non potest in graciliora intestina."

A CASE OF PYÆMIA TREATED WITH SPECIFIC ANTISTREPTOCOCCUS SERUM.

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THIS case appears to me to be worthy of record if only on account of the rarity of pyæmia as a complication of the Lorenz operation for congenital dislocation of the hip.

The patient, a girl aged 2 years 3 months, was admitted to the Hospital for Sick Children, Great Ormond-street, on July 5th, 1911, under the care of Mr. H. A. T. Fairbank, suffering from a congenital dislocation of the right hip. The deformity was very slight. She had commenced to walk at the age of 1 year 6 months. She was a well-nourished, healthy child, without any sign of disease other than the hip deformity.

On July 6th an operation was performed. The patient was anæsthetised with chloroform followed by open ether. The skin having been washed with ether soap and powdered with boric powder the hip was very easily reduced; the adductor muscles were not torn through, and very slight violence was necessary to obtain full abduction. No abrasion or immediate bruising of the skin was caused. On the 8th some bruising in the adductor region appeared, distinctly less than in the average case. Except for slight variation in temperature, which rose to 100° F. on the 14th and to 102° on the 15th, nothing abnormal occurred until the latter date, when œdema and tenderness were apparent over Scarpa's triangle, the œdema involving the right labium majus. A small abscess under the deep fascia in the adductor region was opened and drained, about half an ounce of thin pus being evacuated. The temperature at night was 101°. On cultivation of the pus a pure growth of streptococcus was obtained.

On the evening of July 16th the temperature rose to 104°. The plaster-of-Paris splint having been removed, the abscess was again opened up and found to have tracked down the thigh. Two further incisions were made and very thorough drainage was established. The wall of the abscess was carefully examined and there was no sign of deep extension. The hip-joint itself seemed normal, with no suspicion of fulness or other sign of suppuration. For the next ten days the temperature was about 103° at night and 100° each morning. The patient became extremely toxæmic and rapidly wasted. The wound showed no sign of granulation, and the pus which was discharged was small in amount and contained few leucocytes. On the 26th the left hip-joint filled up with pus and was opened and drained posteriorly. On the 29th the right hip-joint became affected. Both joints were freely opened and drained in front and behind. The patient after the operation was very collapsed, but rallied somewhat after treatment with subcutaneous saline and stimulants. On the 30th a subcutaneous abscess in the left malar region was incised.

On August 2nd suppurative tenosynovitis of a finger developed and the sheath was opened. On the 3rd an acute abscess developed under the left trapezius, tracking under the scapula towards the clavicle. The child was now too ill for general anæsthesia, so after injecting novocaine locally I drained the abscess with three incisions.

From July 21st to August 2nd streptococcus vaccine was administered; at first two doses of a stock polyvalent vaccine, later a specific vaccine which was administered