# REPORTS
TO THE
# SCIENTIFIC GRANTS COMMITTEE
OF THE
# BRITISH MEDICAL ASSOCIATION.

## REPORT ON INTESTINAL SURGERY.[1]

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### Results obtained from an Experimental Investigation into a novel mode of operating, suggested by Professor Senn, of Milwaukee.

The following paper is based upon my clinical experience, and also upon an experimental investigation into the operative procedures suggested by Dr. Senn, of Milwaukee.

Having no licence to perform such experiments, I was obliged to seek the assistance of Mr. Victor Horsley, by whose help I am enabled to lay before you a critical examination of the above-mentioned original and novel lines of treatment.

To my friend, Dr. Dove, Pathologist to the Cancer Hospital, I am indebted for valuable assistance during my investigations, also for the pathological specimens which I am enabled to place before you. Mr. W. B. Carter, Surgical Registrar to the Cancer Hospital, has enabled me by his artistic skill to illustrate my paper with numerous drawings and diagrams.

I propose first to describe the mode of operating as suggested by Dr. Senn in the several operations of (1) *Gastro-enterostomy;* (2) *Jejuno-ileostomy and ileo-ileostomy;* (3) *Enterorrhaphy;* (4) *Ileo-colostomy.*

I shall then narrate my experience as shown by the investigations I have conducted, and compare them with Dr. Senn's experiments, and with the results of similar operations conducted on the lines, at present, followed in this country and on the Continent. I shall discuss how these operations can be applied in practice, and in what forms of obstruction the several operations are applicable; and, finally, I shall make some remarks upon the advantage of operations conducted in this manner over the methods practised at present.

The idea of establishing a fistulous communication between a portion of bowel above and below the seat of an obstruction originated with Maisonneuve, who operated on two patients, but with fatal results in both instances. The operation met with violent opposition at the Surgical Society of Paris—surgeons assuming that the excluded portion of intestine would become the seat of fæcal accumulations which would ultimately destroy the life of the patient, even if he survived the operation. In the year 1863, Hacken, under the direction of Adelmann, made some experiments on dogs, but with no success; and the subject seems to have been completely forgotten until E. Hahn, of Berlin, drew attention to it again in commenting on his two cases of excision of the colon, when circular enterorrhaphy could not be performed, and an artificial anus was established. Both his patients recovered from the operation, but all attempts to close the preternatural opening proved futile.

Now the results of the investigations conducted by Senn, and confirmed by myself, are such as to show that had Hahn practised ileo-colostomy in these two cases, he would not have been driven to form an artificial anus. Further, my investigation proves that in intestinal anastomosis there is no fear of any fæcal accumulation forming in the excluded portion of intestine. If, then, these two points can be established, it becomes evident that the treatment of intestinal obstruction by anastomosis must in the future be the recognised operation in the majority of, if not in all, cases of obstruction of the bowel which cannot be overcome otherwise than by opening the gut.

#### Mode of Operating.

Gastro-enterostomy and jejuno-ileostomy are performed identically in the same way by means of decalcified bone plates such as that shown in Fig. 1. It may be well, before describing the different steps of the operation, to state how these bone plates are prepared.

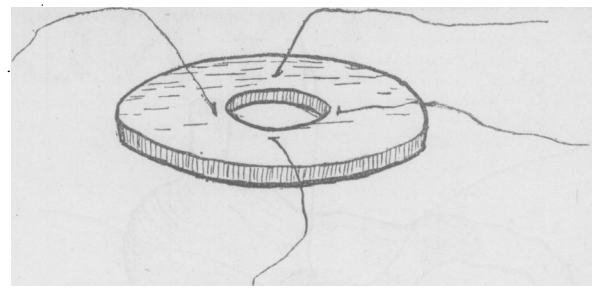

Fig. 1. (About half size.)

The plates are, in the first instance, cut of the requisite size. I have had the ones I used made of uniform dimensions, namely, $2\frac{1}{2}$ inches long by 1 inch wide and $\frac{1}{4}$ inch thick. When decalcified these plates can be easily cut to the size required at the time of the operation. They should have an oval opening in the centre $\frac{3}{4}$ inch long by $\frac{1}{2}$ inch in width. To decalcify them let them be placed in a 10 per cent. solution of strong hydrochloric acid, and allow them to remain in this until they are quite soft and pliable; the acid solution requires to be changed about every second day, and usually the plates are thoroughly decalcified in the course of a week. They are then washed, and allowed to lie in plain water for some hours to get rid of the superfluous acid, and finally they are preserved in rectified spirit until required for use, when they should be placed in a 20 per cent. solution of carbolic acid for an hour before using them. In preparing these plates for operative purposes, four holes have to be drilled in them close to the edge of the central oval opening, namely, one on either side and one at each end. Through these openings four threads at least 12 inches long of No. 1 chromicised catgut or Chinese silk, each armed with a fine sewing needle, are passed and fastened to a circular thread at the back, of the same material, which is formed so as to be a trifle larger than the oval opening. The plates being now ready for use are placed in a solution of carbolic acid.

*Gastro-enterostomy.*—In performing this operation, an opening some three inches in length is made in the middle line of the abdomen, between the ensiform cartilage and umbilicus, the omentum being pushed on one side; a piece of jejunum, as near to its origin as practicable, is drawn into the wound and held by an assistant; a portion of the stomach, about two inches from the greater curvature and as near to the pyloric end as possible, is also drawn into the wound. Two pieces of india-rubber tubing are next passed through the mesentery, about four inches apart, one on either side of the portion of gut to be opened, and, after this has been emptied of its contents by gently squeezing it, these india-rubber tubes are fastened sufficiently tightly to prevent the contents passing. This end might be also attained by the use of Makin's or some other clamp, or, indeed, by an assistant's thumb and fingers, but I prefer the india-rubber tube as described.

The portion of the stomach and intestine being now well outside of the wound, are packed round with sponges to catch any of their contents that might escape on their being opened. An opening about an inch in length is now made in a longitudinal direction into the convex surface of the jejunum, and one of the bone plates slipped in; the needles of the two lateral threads are then passed through all the coats of the bowel close to the cut edge, and unthreaded, the two end threads being brought out at either end of the wound in the gut; these threads are then given to an assistant to hold, while the surgeon makes another incision into the stomach parallel to the greater curvature; the other bone plate is then passed into this viscus through the incision, the needles of the lateral threads are passed through all the coats of the stomach, the end threads being, as in the jejunum, brought out through the wound. (Fig. 2).

The two openings are next accurately adapted to each other, and the bone plates held firmly in position by an assistant while the surgeon ties the corresponding threads of either plate tightly. The lower lateral threads should be tied first, then the end ones, and finally the upper lateral. Should the ends of the bone plates be found to tilt it is wise to insert a Lembert suture at each end, but this is not always necessary. The jejunum being now firmly fixed

[1] Read before the Royal Medical and Chirurgical Society.

to the stomach, the parts are dropped back into the abdominal cavity, the toilet of the omentum attended to, and the abdominal wound closed in the usual manner.

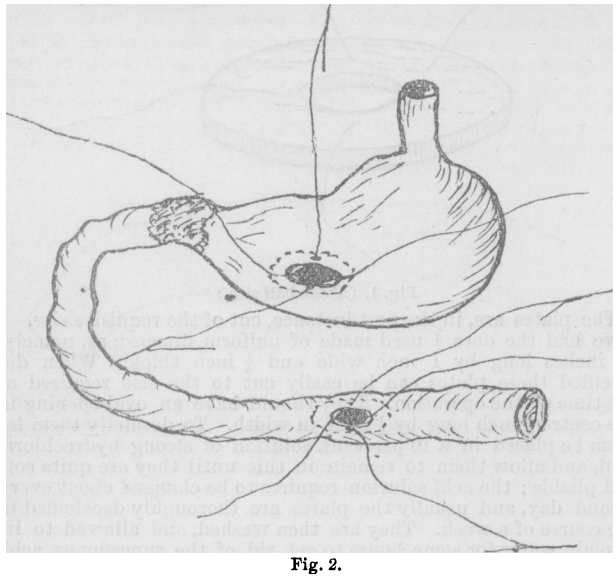

Fig. 2.

This operation can be performed easily in from fifteen to twenty minutes, instead of an hour and a half to two hours, as is usual under the system at present practised. In two cases in which Mr. V. Horsley and I performed gastro-enterostomy on dogs, the operation was accomplished with great ease and rapidity, and, in both cases, the dogs made an uninterrupted recovery, never having displayed the slightest pain or inconvenience. These specimens showed the operation in both cases was perfect. (Fig. 3). (*Vide* notes of cases Appendix).

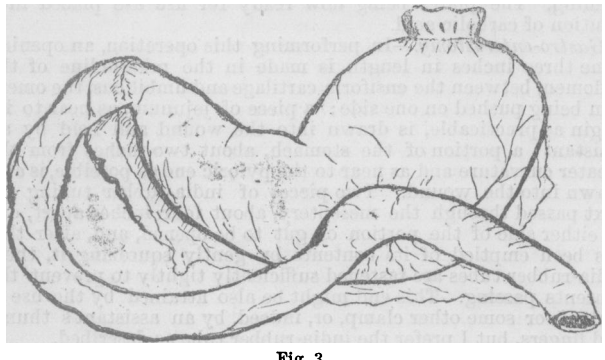

Fig. 3.

*Jejuno-ileostomy.*—If it is not desired to remove any portion of the diseased intestine, but simply to form an artificial communication between a portion of intestine above an obstruction and another portion below, the operation is conducted exactly in the same manner as that described for gastro-enterostomy. Should it, however, be deemed necessary to excise a portion of the gut, the operation will have to be modified somewhat. In this case, the intestine being drawn well out of the abdominal wound and gently squeezed at the seat of the operation, to empty it of its contents as far as possible, should be clamped, either by means of india-rubber bands or one of the numerous clamps devised for the purpose, about four inches on either side of the portion of diseased or injured bowel to be removed. Sponges should be carefully packed round the opening into the abdomen to prevent any fæcal matter that may escape from the divided intestine entering into the peritoneum, and the bowel cut directly across with scissors, and a V-shaped piece of mesentery also removed. All bleeding points being secured with fine catgut ligatures, the two ends of each portion of bowel are to be invaginated into themselves, and, when invaginated to the extent of one inch, the serous and muscular coats of each are stitched together by means of a continuous catgut or Chinese silk suture. The two ends of the gut are next placed parallel to each other (Fig. 4),

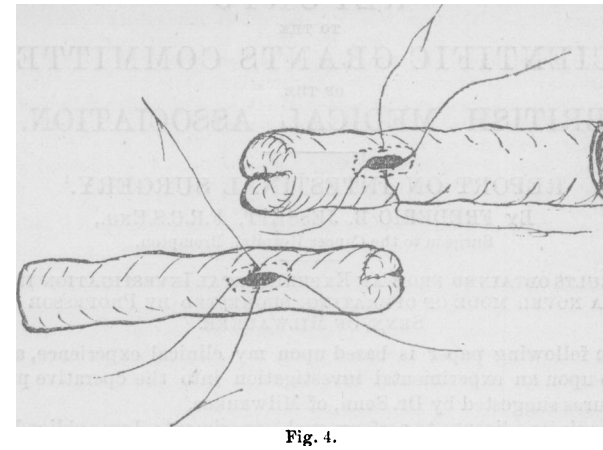

Fig. 4.

with their convex surfaces in apposition. It is of importance to notice that the two portions of intestine are applied end on, so as not to interfere with the peristaltic action of the bowels. An opening about an inch long is made longitudinally in each portion of the gut on its convex surface, and the bone plates passed in and fastened in the same manner as already described for gastro-enterostomy. The divided mesentery is united by a few stitches of catgut. This operation can be easily performed in twenty minutes.

I have performed jejuno-ileostomy or ileo-ileostomy on dogs in six cases. In every case portions of intestine varying in length from three to twelve inches were removed; the two ends of the divided bowel were invaginated into themselves, and in five cases the convex surfaces of the intestines above and below the excised portion were brought into apposition by means of decalcified bone plates. All these dogs made an uninterrupted recovery, and never seemed to suffer the slightest pain or inconvenience from the operation.

At the *post-mortem* examination the omentum was found to be adherent to the bowel at the seat of operation. The two portions of intestine were united (Fig. 5.), and there existed a good and sufficient opening between them to allow of the contents of the bowel passing. In every case the dogs increased in weight after the operation. (*Vide* Appendix.)

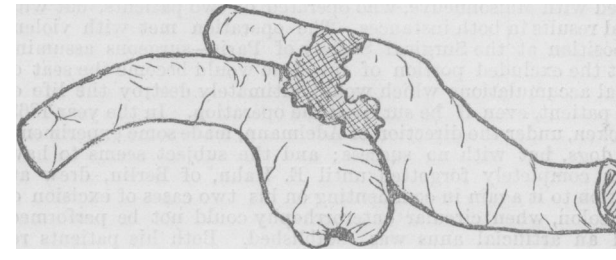

Fig. 5.

The sixth case was operated on in a similar manner to that to be directly described for ileo-colostomy—namely, by implantation of the proximal into the distal portion of the divided intestine. This dog unfortunately died on the third day, through the misfortune of one of the ligatures slipping from a vessel in the mesentery, hæmorrhage resulting. There was no leakage at the points of union of the two portions of gut, which were united by plastic lymph.

### Circular Enterorrhaphy.

This method suggested by Senn and adopted in the investigations we are considering is really a modification of Jobert's operation. In both operations, the proximal portion of the divided gut is invaginated into the distal end, and the sutures are passed through all the coats of the intestine, but Senn's operation differs from Jobert's in that he lines the upper end of the bowel with a soft pliable india-rubber band, which is cut the required length at the time of the operation and formed into a ring by fastening the

ends together with two catgut sutures. The rings that I have used have been formed of a broad flat band of india-rubber, one quarter to a half inch in depth; this is pushed into the lumen of the proximal end of the gut, which it should fit accurately. The ring is to be fastened to the lower end of the proximal portion of the bowel by a continuous catgut suture which prevents the bulging of the mucous membrane. Two chromicised catgut sutures about 18 to 24 inches long and threaded at either end with an ordinary sewing needle are next prepared, and the needle passed from within outwards, transfixing the upper portion of the rubber ring and all the coats of the bowel. The posterior threads are passed one on either side of the mesentery, and the anterior needles at equal distances apart through the convex surfaces of the bowel.

The intestine above and below the seat of operation is either compressed between the thumb and fingers of an assistant, or by an india-rubber band passed round and lightly tied, or by one or other of the clamps made for this purpose.

The needles are next passed through the peritoneal and muscular coats of the lower portion of the intestine at corresponding points about one third or half an inch from the cut edge. An assistant now makes gentle traction upon all the threads, while the operator manipulates the two ends of the divided gut, so that the upper end becomes invaginated into the lower (Fig. 6). Care must be taken that the margins of the lower end are turned completely and evenly in, so that the serous surface of the intussuscipiens is in close contact to that of the intussusceptum. The operator having satisfied himself that the upper portion of gut is completely invaginated, proceeds to tie the catgut sutures with sufficient firmness to prevent disinvagination.

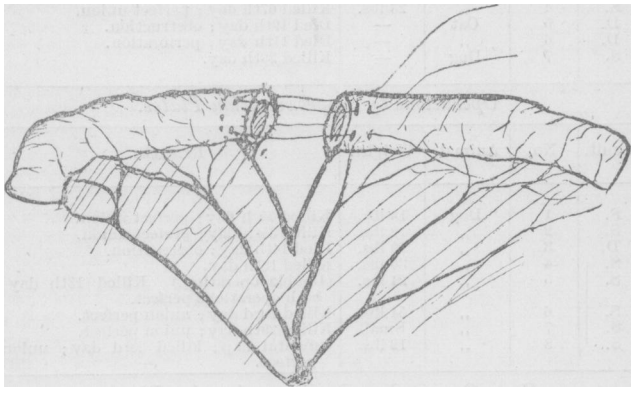

Fig. 6.

The divided mesentery is next fastened together with a few interrupted catgut sutures, and great care should be paid to the mesenteric attachment of the gut at the point of operation, as it is here that the greatest difficulty is experienced in the invagination; in my experience it is always well to place a couple of Czerny-Lembert sutures, one on either side of the mesenteric attachment. After a few days the rubber-ring becomes detached, by the absorption of the catgut sutures, and passes *per anum*.

The success of this operation can be greatly increased, I think, by applying either an omental flap or an omental graft around the seat of operation.

An omental flap adopted by Senn and others, may be applied by cutting a strip of omentum about two inches wide and wrapping it round the gut, fastening it in place by a couple of stitches, one on either side of the point of union of the intestine, and passing through both surfaces of the flap and the mesentery, care being taken to ensure that the sutures are passed parallel to the mesenteric vessels. The cut edge of the omentum from which the flap has been excised, after all bleeding points have been secured, should be united by a continuous catgut suture. In the case of an omental graft a piece of omentum about two inches wide is entirely cut away of sufficient length to wrap easily round the bowel; this then being washed in a weak solution of carbolic acid is fastened round the seat of operation in the same manner as the flap, the cut omentum being united by a continuous catgut suture. Dr. Weir, of New York, suggests that a peritoneal graft might be formed out of the mesentery which has been cut away. In some of my specimens it is seen how well this method has answered (Fig. 7).

Of the seven investigations of this mode of performing circular enterorrhaphy, the two first died from peritonitis due to leakage at the mesenteric attachment three days after the operation. In one of these the distal portion of intestine was invaginated into the proximal by accident. The third case died on the fourteenth day. In this case an omental flap was applied; at the *post-mortem* examination union of the gut was found to be perfect, as also of the omental flap, but the upper end of the bowel was filled with small pieces of hay mixed with other food which the animal had eaten. This had formed a complete block. The india-rubber ring had disappeared, and on removal of the accumulation, the lumen of the gut was found to be perfect.

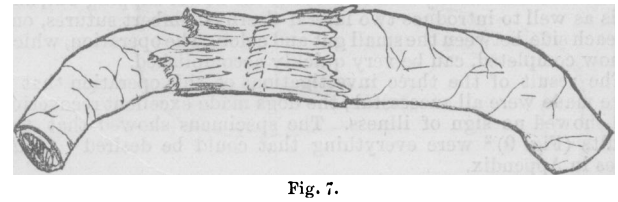

Fig. 7.

The remaining four cases all recovered, although in the last one, in which the omental graft had been applied, the dog wasted considerably, and when killed two months after the operation it was discovered that the portion of bowel above the seat of operation in this dog was also enormously distended and filled with pieces of hay and *débris*.

This operation is very much more difficult in dogs than in human beings. I have performed it a number of times on the dead body with perfect ease; and in one case, that of removal of a sarcomatous ovary in which a large portion of small intestine was involved, I was obliged to remove some twelve inches of intestine; in this case I performed circular enterorrhaphy by this method with perfect ease in a few minutes. This patient was in so exhausted a condition that it would have been impossible to have allowed time to suture the two ends by the Czerny-Lembert method.

The patient did remarkably well for eight days, taking her food freely, and her bowels acting regularly, when she suddenly developed peritonitis, and died on the tenth day after operation. In this case there had been ulceration along one of the sutures. At the *post-mortem* examination it was found that the invagination was perfect, but a small pinhole existed in the mesenteric side of the gut due evidently to ulceration. The india-rubber ring was *in situ:* the catgut sutures fastening the lower edge of the upper end of the intestine to the rubber band were not absorbed, thus forming a valve. From this lesson one learns, the desirability of using plain, not chromicised, catgut sutures for stitching the ring to the margin of the bowel.

### Ileo-Colostomy.

This operation may be accomplished either by approximation plates, the same as described for jejuno-ileostomy, or by the following method:—

The ileum being divided a short distance from its junction with the

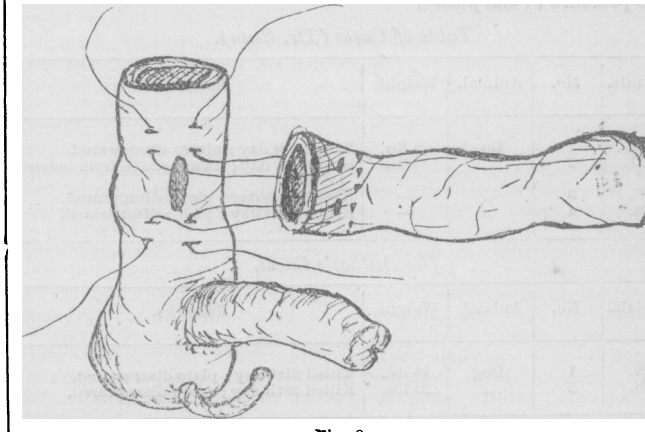

Fig. 8.

cæcum, and all bleeding points ligatured, the divided end of the lower

portion of bowel is invaginated into itself and secured by a continuous catgut suture passing through the serous and muscular coats only. The upper portion, being held by an assistant or secured by an india-rubber ring or clamp to prevent the escape of its contents, is lined with a thin india-rubber ring and two long sutures armed at each end with a needle passed in a similar manner to that described for circular enterorrhaphy. Next a slit an inch in length, or sufficiently long to allow the portion of intestine to be implanted, is made on the convex surfaces of the ascending colon (Fig. 8). The needles of the sutures connected with the small bowel are next passed through the perineal and muscular coats of the colon at either end of the opening and the small bowel inserted into the slit; the two sutures are next firmly tied to prevent the bowel slipping out, and it is as well to introduce two lateral Czerny-Lembert sutures, one on each side, between the small gut and colon. The operation, which is now completed, can be very quickly accomplished.

The result of the three investigations of this operation that I have made were all successful; the dogs made excellent recoveries and showed no sign of illness. The specimens showed that the results (Fig. 9)[2] were everything that could be desired (*Vide* cases in Appendix.

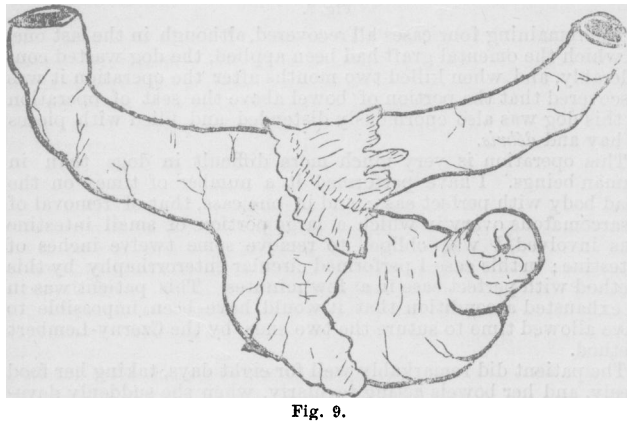

Fig. 9.

So much for the method of performing the different operations, I will now pass to an analysis of the operations as performed by Dr. Senn and compare them with my own experience.

### Gastro-Enterostomy.

Dr. Senn has reported five cases in which he performed the operation of gastro-enterostomy by means of decalcified bone plates. Three of these recovered without any bad symptoms and one died, the cause of death being attributed to the dog's stomach being full at the time of the operation. The omentum became soiled, and much of it was cut away. At the *post-mortem* one of the ligatures was found to have slipped, and hæmorrhage ensued. In two cases operated on by Mr. V. Horsley and myself both recovered without bad symptoms.

In no case was any injury caused to the mucous membrane by the pressure of the plates.

*Table of Cases (Dr. Senn).*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| S. | 1 | Dog | 25 lbs. | Killed 7th day; plates disappeared. |
| D. | 2 | ,, | 50 lbs. | Died next day; hæmorrhage from omental flap. |
| S. | 3 | ,, | — | Killed 34th day; plates disappeared. |
| S. | 4 | ,, | — | Killed 14th day; plates disappeared. |

*The Author's Cases.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| S. | 1 | Dog | 15 lbs. | Killed 21st day; plate disappeared. |
| S. | 2 | ,, | 26 lbs. | Killed 28th day; plate disappeared. |

[2] A series of pathological specimens of these operations are now in the Museum of the College of Surgeons.

In the second case the jejunum was fastened to the posterior wall of the stomach by tearing through the gastro-colic omentum and transverse meso-colon, and drawing a portion of the jejunum through the meso-colic opening.

### Jejuno-Ileostomy.

In the operation of jejuno-ileostomy performed by Dr. Senn, in seven cases the divided intestine was united by Czerny-Lembert sutures; five of the dogs died, three directly from the operation, and two from obstructions caused by enterolith; the remaining two made good recoveries. Senn then operated upon eight dogs by means of approximation plates; of these, seven recovered, and one died fourteen days after the operation, from the obstruction caused by the presence of an enterolith, the result of the dog eating his bed.

The five dogs operated on by Mr. V. Horsley and myself by means of approximation plates all recovered; and the one case in which the operation was performed by means of implantation of the upper segments into the lower, the dog died from hæmorrhage due to the slipping of one of the ligatures on the third day.

*Table of Dr. Senn's Cases of Jejuno-Ileostomy, in which the Visceral Wounds were United by Czerny-Lembert Suture.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| D. | 1 | Cat | — | Died same day. |
| D. | 2 | Dog | 65 lbs. | Died third day. |
| D. | 3 | ,, | 17 lbs. | Died third day. |
| S. | 4 | ,, | 23 lbs. | Killed 67th day; perfect union. |
| D. | 5 | Cat | — | Died 19th day: obstruction. |
| D. | 6 | ,, | — | Died 11th day; perforation. |
| S. | 7 | Dog | — | Killed 20th day. |

*Operations by Approximation Plates.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| S. | 1 | Dog | 15 lbs. | Killed 75th day; perfect union. |
| S. | 2 | ,, | 18 lbs. | Killed 35th day; perfect union. |
| D. | 3 | ,, | 10 lbs. | Died 14th day; obstruction. |
| S. | 4 | ,, | 30 lbs. | Killed 18th day. |
| S. | 5 | ,, | 24 lbs. | (Double operation.) Killed 13th day both operations perfect. |
| S. | 6 | ,, | 54 lbs. | Killed 23rd day; union perfect. |
| S. | 7 | ,, | Small | Killed 29th day; union perfect. |
| S. | 8 | ,, | 12 lbs. | Omental flap; killed 23rd day; union perfect. |

*Cases Operated on by Approximation Plates.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| S. | 1 | Dog | 32 lbs. | Killed 14th day; perfect union. |
| S. | 2 | ,, | 15 lbs. | Killed 14th day; perfect union. |
| S. | 3 | ,, | 18 lbs. | Killed 18th day; perfect union. |
| S. | 4 | ,, | 26 lbs. | Omental flap; killed 14th day; perfect union. |
| S. | 5 | ,, | 23 lbs. | Killed 56th day; perfect union. |

*One Case of Intestines United by Implantation.*

| Result. | No. | Animal. | Weight | Remarks. |
|---|---|---|---|---|
| D. | 1 | Dog | 15 lbs. | Died third day; hæmorrhage. |

These cases are very significant and instructive, for here we have fifteen cases operated on by Dr. Senn, exactly under the same circumstances, and, I presume by the same operator, in seven of which the divided intestines were united by suturing the two ends together by means of Czerny-Lembert sutures, and in the remaining eight the ends were united by approximation plates. Of the dogs operated on by the former method, five died, while in all of those operated on by means of the approximation plates, only one died, and that not directly from the operation, and this experience is fully confirmed by Mr. V. Horsley and myself, as in five cases operated on by us in which the ends of the intestines were united by approximation plates all recovered.

Taking, then, into consideration the excessively low mortality

of this operation when performed by approximation plates, the very short time the operation takes to perform, namely, only about twenty minutes, and comparing it with the results of the same operation carried out by suturing after Czerny-Lembert's method, which operation cannot be done under an hour and a half to two hours, I think there cannot be any question as to the value of the operation as proposed by Senn.

### Enterorrhaphy by Invagination.

This operation is undoubtedly more difficult to perform than the operation by means of approximation plates, and the mortality after the operation is certainly larger, as will be seen by the accompanying tables. It will be noticed, however, by the report of cases performed by Mr. V. Horsley and myself, that two factors play an important part in the success of the operation, viz.: First, practice, for out of the seven cases that were operated upon, it was the first two which died immediately from the effects of the operation; the third died from the bowel above the seat of operation being blocked by an accumulation of hay and *débris*, while the remaining four all recovered. The second factor is undoubtedly the use of the omental flap or graft, wrapped round the seat of operation.

Another point I would draw attention to in this operation, as experience has taught me, is that in all future cases on the human subject, I would advise the use of ordinary catgut sutures for fastening the india-rubber ring to the end of the bowel, and also for passing through the coats of the intestines; and, finally, I would suggest that three Chinese silk Czerny-Lembert sutures should be inserted to unite the two ends of the divided bowel, one on each side of the mesentery, and one in the convex surface of the intestine, to prevent the possibility of the bowel becoming disinvaginated.

The use of ordinary catgut sutures would prevent the possibility of the india-rubber ring being retained too long, and thus becoming a source of obstruction, and yet they would last a sufficiently long time to allow of plastic lymph being thrown out between the two approximated serous surfaces.

I would here like to point out that in all cases of obstruction there would be considerable difficulty in performing enterorrhaphy by invagination, as in such cases the proximal end of the bowel is of necessity greatly dilated, while the portion of bowel below the obstruction is correspondingly contracted, so that the difficulty of invaginating the dilated into the contracted portion would be very great. This objection would not apply to union by means of approximation plates.

*Dr. Senn's Cases of Enterorrhaphy by Invagination.*

| Result. | No. | Animal. | Weight. | Length of Invagination. | Remarks. |
|---|---|---|---|---|---|
| S. | 1 | Dog | 15 lbs. | 1 inch | Killed 14th day; omentum adherent. |
| D. | 2 | ,, | 20 lbs. | ,, | Large enterolith found. |
| D. | 3 | ,, | 40 lbs. | ,, | Died 3rd day; lower end invaginated by mistake into the upper. |
| D. | 4 | ,, | ,, | ,, | Died 36 hours; gangrene. |

*Cases in which Omental Flap was Used.*

| Result. | No. | Animal. | Weight. | Length of Invagination. | Omental Flap. | Remarks. |
|---|---|---|---|---|---|---|
| S. | 5 | Dog | 40 lbs. | ½ inch | 1 inch | Killed 14th day; omental flap found adherent. |
| D. | 6 | ,, | 20 lbs. | ,, | 2 inches | Died 5th day; perforation. |
| S. | 7 | ,, | 15 lbs. | ,, | ,, | Killed 25th day; omental flap adherent. |
| S. | 8 | ,, | 22 lbs. | ,, | ,, | Killed 23rd day; omental flap adherent. |
| S. | 9 | ,, | 15 lbs. | ,, | ,, | Killed 44th day; omental flap adherent. |

*The Author's Cases.*

| Result. | No. | Animal. | Weight. | Length of Invagination. | Omental Flap. | Remarks. |
|---|---|---|---|---|---|---|
| D. | 1 | Dog | 15 lbs. | ½ inch | — | Died third day; perforation. |
| D. | 2 | ,, | 12 lbs. | ,, | — | ,, ,, ,, |
| D. | 3 | ,, | 20 lbs. | ,, | om. flap | Died 14th day; enterolith. |
| S. | 4 | ,, | 16 lbs. | ,, | — | Killed 14th day; perfect union. |
| S. | 5 | ,, | 20 lbs. | ,, | — | Killed 21st day; perfect union. |
| S. | 6 | ,, | 18 lbs. | ,, | om. flap | Killed 56th day; perfect union. |
| S. | 7 | ,, | 27 lbs. | ,, | — | Alive and well 3 months after operation. |

It will be seen, then, that in the nine operations reported by Dr. Senn four were performed without an omental flap, three of which died. It is right to point out, however, that only one died directly from the operation, the other two dying one from the pressure of an enterolith eighty-one days after the operation, and the other from a faulty operation, the lower end of gut being invaginated into the upper by mistake. Of the remaining five operations—all had either an omental graft or flap; of these, only one died of perforation.

Of the seven operations performed by Mr. Horsley and myself, the two first died directly from the operation, the first from the lower portion of bowel being invaginated into the upper by mistake, and the third succumbed to obstruction caused by an enterolith, the result of the dog eating his bed, the remaining four making excellent recoveries.

### Ileo-Colostomy.

Of this operation Dr. Senn has reported sixteen cases, six of which were performed by implantation, the end of the ileum being lined with india-rubber band; of these two died, one of septic peritonitis and the other of perforation; in seven dogs the operation was performed by lateral approximation, the two portions of gut being united by Czerny-Lembert sutures; of these two died of septic peritonitis; in the remaining three the union of the ileum and colon was accomplished by means of approximation discs; of these one died of peritonitis.

Mr. Victor Horsley and I have performed this operation in three cases, adopting in each case the method by implantation. All three cases made a perfect and speedy recovery; one dog was not killed until twenty weeks after the operation. The dogs always had perfect health, and got very fat.

Dr. Weir, of New York, has collected and reported thirty-five resections of the large intestine, the mortality from which, when the symptoms of obstruction demanded laparotomy, amounted to 100 per cent. Surely in many of these cases had the operation

*Dr. Senn's Cases.*

*First Series by Implantation, the end of the Ileum being Lined with a Band of India-rubber.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| D. | 1 | Dog | 50 lbs. | Died on fifth day; septic peritonitis. |
| S. | 2 | ,, | 35 lbs. | Omental flap; killed 13th day; union perfect. |
| S. | 3 | ,, | 16 lbs. | Omental flap; killed 43rd day; union perfect. |
| S. | 4 | ,, | — | None; killed 23rd day; union perfect. |
| S. | 5 | ,, | 14 lbs. | Omental flap; killed 18th day; union perfect. |
| D. | 6 | ,, | — | Omental flap; died 3rd day. |

*Second Series by Lateral Approximation; Czerny-Lembert Sutures.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| S. | 1 | Dog | 25 lbs. | Killed 37th day; union perfect. |
| S. | 2 | Cat | — | Killed 162nd day; union perfect. |
| D. | 3 | ,, | — | Died 4th day; peritonitis. |
| S. | 4 | Dog | — | Killed 31st day; union perfect. |
| S. | 5 | ,, | — | Killed 41st day; union perfect. |
| S. | 6 | ,, | 27 lbs. | Killed 31st day; union perfect. |
| D. | 7 | ,, | 17 lbs. | Died 5th day; septic peritonitis. |

*Third Series, Lateral Union by Approximation Plates.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| D. | 1 | Dog | 20 lbs. | Died 5th day; peritonitis. |
| S. | 2 | ,, | 15 lbs. | Killed 24th day; union perfect. |
| S. | 3 | ,, | 15 lbs. | Killed 18th day; union perfect. |

*The Author's Cases by Implantation.*

| Result. | No. | Animal. | Weight. | Remarks. |
|---|---|---|---|---|
| S. | 1 | Dog | 18 lbs. | Killed 140th day; union perfect. |
| S. | 2 | ,, | 20 lbs. | Killed 18th day; union perfect. |
| S. | 3 | ,, | 18 lbs. | Killed 21st day; union perfect. |

of ileo-colostomy been performed, either with or without resection of the diseased portion of intestine, the patients might have derived considerable relief, their lives might have been prolonged, and, in some cases, complete cure might have been effected.

It will be seen from the above tables that the operation by implantation and by apposition of the two portions of intestine by means of Czerny-Lembert sutures were about equally successful, but we must not lose sight of the fact that the former operation was performed in something less than a quarter of the time occupied by the latter mode of operating, and in most cases in which such an operation was necessary, the patient being reduced greatly in strength either by prolonged malignant disease or by acute suffering from intussusception or gangrene, the factor of time must necessarily play a most important part.

The operations performed by lateral apposition and approximation discs is not nearly so successful here as in operations on the small intestine, and therefore in the performance of ileo-colostomy I should always recommend the method by implantation to be adopted.

ENTEROSTOMY.

There only remains, then, now one more question to consider, and that is, in operating on the intestine, how much of the small intestine may be removed without appreciably interfering with the nourishment of the subject operated on. Dr. Senn has operated on seven cases, removing from 12 inches to 96 inches of intestine. Three of these died immediately from the result of the operation; one died twenty-one days after the operation from marasmus (in this case 34 inches of bowel were removed); and in the three that were killed marasmus is reported to have been extreme.

*Table of Dr. Senn's Cases of Enterostomy.*

| No. | Animal. | Weight. | Length of Intestine Removed. | Result. | Remarks. |
|---|---|---|---|---|---|
| 1 | Dog | 22 lbs. | 30 inches | Died 5th day | —— |
| 2 | Cat | — | 12 ,, | ,, same night | —— |
| 3 | Dog | 36 lbs. | 72 ,, | Killed 161st day | Marasmus extreme. |
| 4 | ,, | — | 96 ,, | Died 3rd day | —— |
| 5 | ,, | 10 lbs. | 50 ,, | Killed 47th day | Marasmus extreme. |
| 6 | Cat | 29 lbs. | 29 ,, | ,, 12th day | ,, ,, |
| 7 | ,, | 24 lbs. | 34 ,, | Died 21st day | ,, ,, |

The result being that, in seven cases, two died from the operation, two died from marasmus caused by the operation, and three were killed at different dates, all suffering from extreme marasmus.

To sum up the result of the different operations above described it will be found to be as follows, namely:

Gastro-enterostomy by approximation plates: 6 cases, 1 death, death-rate =16.6 per cent.

Jejuno-ileostomy by approximation plates: 13 cases, 1 death, death-rate =7.69 per cent.

Jejuno-ileostomy by Czerny-Lembert sutures: 7 cases, 5 deaths, death-rate =71.5 per cent.

Enterorrhaphy by invagination without omental flaps: 4 cases, 3 deaths, death-rate =75.0 per cent.; with omental flaps: 12 cases, 3 deaths, death-rate =24.99 per cent.

Ileo-colostomy by implantation: 9 cases, 2 deaths, death-rate =22.2 per cent.

Lateral apposition by Czerny-Lembert sutures: 7 cases, 2 deaths, death-rate = 28 per cent.; by apposition with approximation plates: 3 cases, 1 death, death-rate =33.0 per cent.

And again, by omitting the cases in which the Czerny-Lembert suture was adopted, we have 47 cases operated on either by approximation discs or invagination, with 11 deaths, or at the rate of 23.4 per cent.

Now, let us for one moment compare these results with those cases which are published, and with statistics collected of similar operations performed on the human being. The largest number of cases have been collected by Reichel, who, in the *Deutsche Zeitschrift für Chirurgie*, 1883, p. 230, furnishes the result of 121 cases of resection of the bowel in which the ends were united by Czerny-Lembert sutures; of these, 58 recovered, 58 died, and 5 recovered with fæcal fistulæ, the death-rate being at the rate of 48 per cent. Ill has reported 47 cases, with 25 deaths, being at the rate of 53.1 per cent., while Weir, of New York, has furnished statistics of 33 completed cases of resection of cancerous intestine, with a mortality of 51.5 per cent.

Sir W. Mac Cormac, in his oration delivered at the Medical Society in May, 1887, on Abdominal Section, gives particulars of 13 cases of abdominal section performed for supposed traumatic rupture of the intestines and other abdominal viscera; all these cases died, some from injury to other viscera besides the bowel, some from shock.

Dr. B. Farquhar Curtis, of New York, in a paper read to the New York Medical Society at Albany in February of last year, in connection with a discussion on acute intestinal obstruction, has arranged a table of 308 cases to show the result of the various methods of treatment adopted by the surgeon, or forced upon him by the exigencies of the case with especial reference to this factor. From a study of this table it will be seen that the obstruction was removed and an artificial anus formed in 15 cases, with a mortality of 10, or at the rate of 66.6 per cent. In 45 cases the portion of intestine was resected and the ends sutured; 39 of these cases died, showing a mortality of 86.6 per cent. The obstruction in these 60 cases was caused by either intussusception, volvulus, adhesion, bands or internal incarceration in 42 instances. Dr. Curtis, in referring to the 45 cases in which an attempt was made to suture the wound in the intestines whether it involved the entire circumference of the wound or not, says that the mortality reached the extreme point of 86.6 per cent.; only 10 per cent. of the deaths were from sepsis due to the operation, while more than the usual number—50 per cent.—were due to the condition of the patient, and 23 per cent. were due to the duration of the operation and to shock.[3]

This is surely a strong argument for making the operation occupy as short a time as possible, and I submit that the methods which I have described are those which will in the future, by enabling the surgeon to perform these operations in a quarter or a third of the time occupied by the system at present practised, be the means of saving many valuable lives, and will reduce the mortality to that which is now obtained in ovariotomy and hysterectomy. In most extreme cases many surgeons are contented to perform enterostomy and creating a fæcal fistula or artificial anus. But I contend by performing one of the several operations I have described of ileo-colostomy, jejuno-ileostomy, or enterorrhaphy, any one of which can be accomplished in quite as short a time as that required for the formation of an artificial anus, the surgeon performs a radical operation in the place of a palliative one, and the risk to the patient is not so great, for I have already shown that in the cases in which an artificial anus was formed, reported by Dr. Curtis, the mortality amounted to 66.6 per cent., and then the patient was left either with a permanent fæcal fistula, or would have at some future time to submit to a further operation for its closure.

Now, if we compare the mortality as shown by these statistics with that obtained by Senn's operation as performed by him and confirmed by myself, you will find that, excepting the 7 cases of jejuno-ileostomy performed by Senn by the Lembert suture, 48 operations were performed, with 12 deaths, or a mortality of 25 per cent.; but, again, if you omit the 14 cases in which the operation was performed, but afterwards abandoned for a safer one, the mortality is reduced to 17.6 per cent.

If, then, these figures can be accepted as correct, the mortality from these operations should be reduced from 86.6 to 20 per cent., by adopting the method of operating I have described, and

[3] *Vide* Appendix No. I. Table of cases collected or reported by different observers.

I have no doubt by further experience and practice the death-rate will be reduced very much lower. But it will be argued that these figures are all very well, and we are willing to accept them for what they are worth, but it must not be overlooked that in all the cases you have recorded and in which you claim such brilliant results, the operations were performed on healthy animals, and the analogy between such operations and similar ones performed on a human being exhausted by disease or pain cannot for one moment hold good! True, but Senn has performed the operation of enterorrhaphy by the Czerny-Lembert system on seven healthy animals, five of which died, giving a mortality of 71.5 per cent., or a death-rate within a fraction of what the same operation is credited with on the human subject.

Again, can it for one moment be doubted if two surfaces of peritoneum can be brought into sufficiently close apposition by the operation I am advocating, and this I think I have proved, it cannot make any difference in this respect whether the patient be in health or wasted by disease, and further if these operations can be done in twenty to thirty minutes instead of an hour and a half to two hours, does it not follow that the chances of success must be enormously increased?

We now, then, arrive at the third point for our consideration, namely, *in what form of obstruction of the intestinal tract are these operations applicable?* I think I may say that there is no form of obstruction which cannot be relieved by ordinary manipulation, in which either one or the other of these operations may not be practised with every hope of success.

### Gastro-Enterostomy.

This operation may be practised for an obstruction arising at either the pylorus, the duodenum, or upper part of the jejunum. The principal form of obstruction in which this operation is to be recommended is undoubtedly malignant disease or stricture of the pylorus. In both these forms of disease the patients as a rule are much emaciated and exhausted before they apply for relief; it is then of all importance that any operation should be conducted so as to cause as little shock as possible, and in this case such an end can only be attained by shortening the duration of the operation to its minimum; and this can be attained by the operation I have described, namely, by uniting the stomach and jejunum by approximation plates. The same may be also said with regard to the operation when required for obstruction arising in the duodenum.

It is true that in some forms of fibrous stricture of the pylorus Loreta's operation of opening the stomach and forcibly dilating the stricture has been practised apparently with success, but I would submit that this operation is quite as formidable as that of gastro-enterostomy as practised with approximation discs, and the permanent nature of the relief cannot, I think, be so reliable by the former operation as by the latter.

### Jejuno-ileostomy and Enterorrhaphy by Invagination.

These are operations both of which are applicable to cases of obstruction which necessitate the excision of a portion of small intestine either for gangrene of the gut, direct strangulation (for example, hernia, volvulus) fæcal fistula, or contraction of some portion of the intestine due either to simple stricture or an epitheliomatous growth. Until quite lately, in nearly all such cases the surgeon has been contented to remove the diseased portion of bowel and establish a fæcal fistula, waiting until a future day for the performance of enterorrhaphy by means of Czerny-Lembert sutures, thus exposing the patient to the risk of two operations; and, as I have already shown, each operation is attended with an extremely high mortality.

Of late years, however, surgeons have in several cases excised the diseased portion of intestine, and if circumstances allowed, at once sutured the two ends together either by the Lembert method or Jobert's, or some one of the other numerous plans that have been devised for this purpose by different surgeons.

From the success attained by Professor Senn and myself in our investigation, I venture to think that there is no case, when enterostomy is performed, in which the continuity of the bowel may not be restored at once, with every chance of success, by adopting one of the operations I am now advocating—namely, either by approximation of the two surfaces of the intestine, after their ends have been invaginated into themselves, by approximation discs, or by enterorrhaphy—by invagination of the upper into the lower segment of bowel, after the plan I have laid down. I would further here say that, in my opinion, in very few cases is the surgeon justified in forming a fæcal fistula.

With respect to the choice of these two operations in special cases, I should say, from my experience, that of re-establishing the continuity of the bowel by means of lateral apposition and approximation discs commends itself mostly to my favour, for in all cases of obstruction of the intestine which has lasted for any time the upper portion will be always found to be much dilated, and that portion below the stricture contracted so that it would be most difficult and, in many cases, impossible to invaginate the upper into the lower, whereas the approximation of the convex surfaces of the two ends would be comparatively easy to accomplish.

Again, in cases in which the obstruction is the result of adhesion or matting together of the intestine, which adhesion cannot be broken down without injury to the coats of the bowel, there would usually be no difficulty in adjusting the portion of the intestine above the seat of obstruction in apposition with that below, and securing by means of approximation plates, without the necessity of excising the portion of intestine so bound down or matted together, thus materially diminishing the risk to the patient.

Again, it has been shown that the mortality after this operation is very much less—namely, only at the rate of 7.69 per cent., as against 24.99 per cent. after invagination. This surely, then, must be a convincing proof of the superiority of the one over the other operation.

And, lastly, from the rapidity with which this operation can be performed, occupying as it does considerably less time than would be taken in stitching the open ends of the divided intestine to the abdominal walls to establish a fæcal fistula, it must in the future occupy the most prominent position in all operations for the relief of intestinal obstruction of the small intestine.

### Ileo-colostomy.

This is perhaps the most interesting of all the operations I have described, and it is likely to play a very important part in future surgery for the relief of irreducible intussusception of the ileum into the cæcum and malignant disease of the colon.

Hitherto the only operative means for relief in such cases, if resection be not performed, supposing the abdomen to be opened and, in the one case, the invagination found to be irreducible, or, in the other, the growth such as cannot be removed, has been enterostomy, and the establishing of an artificial anus; but this operation, performed under these circumstances, has been found to offer less chance of recovery than enterostomy for simple stricture of the smaller intestine. As Treves has pointed out (referring to this operation for relief of intussusception), "not only is the obstruction relieved, but a portion of gut is left in the abdominal cavity that may cause fatal mischief. The unreduced intussusception may, in spite of the artificial anus above it, become gangrenous, or its walls may ulcerate, or the inflammation existing in its tissues may lead to fatal peritonitis. It is only by an excision of the involved segment that these evils can be obviated." In thirteen cases of enterostomy, or enterectomy, for intussusception, collected by Mr. M'Ardle, Dublin, ten died, four from gangrene, three from septic peritonitis, and two from exhaustion.

Now, by performing ileo-colostomy by implantation, these difficulties may be overcome, the continuity of the bowel be re-established, and a fæcal fistula avoided. Moreover, in many cases it would not be difficult to remove, through the opening in the colon, the invaginated portion of small intestine.

As we have seen, the mortality of this operation is exceedingly small. Ileo-colostomy might be had recourse to also in all cases where colectomy has to be performed, as it is equally easy to implant a portion of small intestine into the sigmoid flexure, or, indeed, into the rectum, as it is to implant it into the ascending colon, as shown in the specimen in my possession.

Finally, the conclusions to be drawn from what I have said are obvious, namely:

1. Gastro-enterostomy, jejuno-ileostomy, and ileo-colostomy should always be performed by lateral apposition, by approximation decalcified bone plates.

2. But when enterorrhaphy is performed, it should always be by invagination of the upper into the lower portion of the gut, and that continuity of the peritoneal surfaces of the ends of the bowel to be united should be procured, where the mesentery is detached by stitching the peritoneum together over the denuded surface of intestine with fine catgut sutures before the bowel is invaginated.

3. In cases of complete division of the bowel, circular enterorrhaphy is not to be recommended, but the ends of the divided

bowel should be closed by invagination, and the continuity of the canal established by means of lateral apposition and approximation discs.

4. That a fistulous opening should be established between the bowel above and below the seat of obstruction by lateral apposition and approximation discs in all cases where it is deemed inadvisable to remove the obstructed portion of intestine.

5. That an artificial anus should never be formed unless it is found to be absolutely impracticable to re-establish the continuity of the intestinal canal by one of the operations named.

6. That ileo-colostomy or ileo-rectostomy, either by means of approximation discs or implantation, should always be performed in cases of ileo-cæcal invagination which cannot be reduced by gentle traction, or malignant disease of the colon.

7. That omental grafts some two inches wide, or omental flaps, should be adopted in all cases of circular enterorrhaphy, as experience shows these grafts retain their vitality, and become adherent in a few hours.

*List of Authorities Referred to.*—Agnew, *Med. and Surgical Report. Phil.*, 1888, lx, 321; Barker, *Lancet*, 1888, vol. ii, 262; Barton, *Med. and Surgical Report, Phil.*, 1888, 16; Ball, *Dublin Journal of Med. Sciences*, 1888, 3, s. lxxxvi; Robertson, *Glasgow Med. Journal* [4] s. xxx, 215, 18; Bull, *Gaillard Med. Journal, New York*, 1888, xiv, 254; Penrose, *Med. and Surg. Report. Phil.*, 1888, lviii, 273; M'Ardle, *Dublin Journal Med. Scien.*, 1888, 3, s. lxxxv, 1—123; Morton, *Med. News, Phil.*, 1887, li, 729; Robertson, *Med. News, Phil.*, 1888, xviii, 431; Robertson, *Med. News, Phil.*, 1888, xviii, 429; Barton, *Liverpool Med. and Chir. Journal*, 1888, viii, 309; Curtis, *Med. Record, New York*, 1888, xxiv, 233; Park, *Med. Record, New York*, 312-15; Gaston, *Med. Record, Atalanta*, 1888, xviii, 201; Homan, *Inter. Med. Congress*, 1887, vol. i, 486-535; Senn, *Annals of Surgery*, vol. i, 1888, and *Inter. Med. Congress*, 1887, vol. i; Von Dunluff, *Smith Med. Record, Atalanta*, 1888, 209; Schebe, *Archiv klin. Chir.*, 1887, xxxvi, 646; Fühe, *Münch. med. Wochenschr.*, 1887, 156.

## APPENDIX A.

### Statistics of Operations for Diseases and Obstructions of Intestines.

*Table of Cases of Enterectomy and Enterostomy with Artificial Anus. Collected by Mr. F. B. Jessett.*

| No. | Authority. | Operation. | Result. | Reference. |
|---|---|---|---|---|
| 1 | Barton | Excision of three inches of intestine for epithelioma of ileo cæcal valve; artificial anus | Recovered | *Med. and Surg. Report. Phila.*, 1888, p. 16. |
| 2 | ,, | Laparotomy; artificial anus for obstruction of bowel by encephaloid growth | Died 14th day, peritonitis | ,, |
| 3 | Mayne | Abdominal section for acute intestinal obstruction; artificial anus. Operation five days after first symptom | Recovered | *Lancet*, 1888, vol. ii, p. 512. |
| 4 | Bennett | Laparotomy; artificial anus for cancer of cæcum | Died | *Lancet*, 1888, vol. ii, p. 869. |
| 5 | Bull | Abdominal section; artificial anus for cancer of sigmoid flexure | Recovered | *New York Med. Journ.*, vol. xiv, p. 254 |
| 6 | — | Abdominal section; artificial anus; cancer of rectum | ,, | *New York Med. Journal*, vol. xxxiii, p. 205. |
| 7 | — | Abdominal section; artificial anus; cancer of sigmoid flexure | Died | ,, |
| 8 | — | Abdominal section; artificial anus; acute intestinal obstruction by peritoneal band | Recovered | ,, |
| 9 | President of Pathol. Section, Dublin | Abdominal section; artificial anus; excision of portion of cancerous intestine | Died | *Dublin Journ. of Med. Science*, 1888, p. 145. |
| 10 | ,, | Abdominal section; artificial anus; cancer of intestine | ,, | ,, |
| 11 | Homan | Abdominal section; artificial anus; gunshot wound and intestinal obstruction | ,, | *Int. Med. Congress*, 1887, vol. i, p. 533. |
| 12 | ,, | Abdominal section; artificial anus; cancer of intestine | ,, | ,, |
| 13 | ,, | ,, ,, ,, | ,, | ,, |
| 14 | ,, | ,, ,, ,, | Recovered | ,, |
| 15 | Penrose | Abdominal section; artificial anus; cancer of descending colon; resection of diseased intestine. | ,, | *Med. and Surg. Report. Phila.*, 1888. vol. lviii, p. 273. |

15 Cases. 8 Deaths = 53.3 per cent.

*Enterectomy and Union of Divided Ends of Intestine by Czerny-Lembert Suture.*

| No. | Authority. | Operation. | Result. | Reference. |
|---|---|---|---|---|
| 1 | Agnew | Excision of 14 inches of ileum with V-shaped piece of mesentery | Died next day; stitches broke down | *Med. and Surg. Report Phila.* vol. lix, 321. |
| 2 | Atkinson | Rupture of intestine; portion excised and ends united | Died 2nd day; purulent peritonitis | *Lancet*, 1888, vol. i, p. 1295. |
| 3 | Sinclair | Enterectomy for artificial anus; portion of bowel resected | Recovered | BRITISH MEDICAL JOURNAL, 1888, vol. i, p. 1158. |
| 4 | Bennett | Cancer of colon; excision of diseased portion | Died | *Lancet*, 1888, vol. ii, p. 869. |
| 5 | ,, | Acute intestinal obstruction; excision of portion of bowel | ,, | ,, |
| 6 | Bull | Acute intestinal obstruction; loop of 8 inches of intestine removed | Died 20 hours after operation | *New York Med. Journal*, vol. xxxiii, p. 205. |
| 7 | ,, | Acute intestinal obstruction; loop removed | Died | ,, |
| 8 | ,, | Acute intestinal obstruction; excision of loop | ,, | *New York Med. Journal*, vol. xiv, p. 254. |
| 9 | Park | Gunshot wound | ,, | *Medical News, Phila.*, p. 1888, vol. liii, p. 116 |

9 Cases. 8 Deaths = 88.8 per cent.

*Cases of Enterostomy and Enterectomy with Lembert Suture for Gangrenous Hernia.*

| Authority. | No. of Cases. | Results. | | Mortality. | Reference. |
|---|---|---|---|---|---|
| | | Recovered. | Died. | | |
| Collected by M'Ardle | 76 | 35 | 41 | 54 per cent. | *Dublin Journal of Medical Science*, 1888, s. lxxxv., pp. 1-123. |

| Cause of Death. | No. |
|---|---|
| From yielding of sutures ... ... ... ... | 11 |
| ,, exhaustion ... ... ... ... ... | 8 |
| ,, carbolic poisoning ... ... ... ... | 2 |
| ,, asphyxia ... ... ... ... ... | 2 |
| ,, septic peritonitis ... ... ... ... | 12 |
| ,, simple ,, ... ... ... ... | 3 |
| Not noted ... ... ... ... ... | 3 |
| Total ... ... ... | 41 |

*Cases of Enterostomy and Enterectomy for Intussusception.*

| Authority. | No. of Cases. | Died. | Mortality. | Reference. |
|---|---|---|---|---|
| Collected by M'Ardle | 13 | 10 | 77 per cent. | *Dublin Journal of Medical Science*, 1888, s. lxxv., pp. 1-123. |

| Cause of Death. | No. |
|---|---|
| From gangrene of suture line ... ... ... | 4 |
| ,, septic peritonitis ... ... ... ... | 3 |
| ,, exhaustion ... ... ... ... ... | 2 |
| Not specified ... ... ... ... ... | 1 |
| Total ... ... ... | 10 |

*Cases of Laparotomy for Intussusception.*

| Authority. | No. of Cases. | Died. | Mortality. | Reference. |
|---|---|---|---|---|
| Collected by A. Barker | 73 | 60 | 82.2 per cent. | *Lancet*, 1888, vol. ii, p. 262 |

| Cause of Death. | No. |
|---|---|
| From bowel released ... ... ... ... | 22 |
| ,, intussusception irreducible ... ... ... | 5 |
| ,, ,, resected ... ... ... | 7 |
| ,, artificial anus formed ... ... ... ... | 10 |
| ,, ,, ,, without laparotomy ... ... | 10 |
| Not mentioned ... ... ... ... ... | 6 |
| Total ... ... ... | 60 |

*Cases of Acute Intestinal Obstruction Treated by Resection and Lembert Suture.*

| Authority. | No. of Cases. | Died. | Cause of Death. | Reference. |
|---|---|---|---|---|
| Collected by M'Ardle | 5 | 4 | Not mentioned. | *Dublin Journal of Medical Science*, 1888, s. lxxxv, pp. 1-123. |

*Cases of Enterectomy or Enterorrhaphy for Intestinal Obstruction caused by Cancer or other Cause.*

| Authority. | No. of Cases. | Died. | Cause of Death. | Reference. |
|---|---|---|---|---|
| Collected by M'Ardle | 27 | 14 | Mostly with pyæmic symptoms; 5 of the cancer cases had secondary deposits. | *Dublin Journal of Medical Science*, vol. lxxxv, pp. 1-123. |

*Cases of Resection for closing Artificial Anus.*

| Authority. | No. of Cases. | Died. | Cause of Death. | Reference. |
|---|---|---|---|---|
| Collected by M'Ardle | 49 | 6 | Septic peritonitis. | *Dublin Journal of Medical Science*, vol. lxxxv. |
| | | 4 | Simple ,, | |
| | | 4 | Collapse. | |
| | | 3 | Obstruction. | |
| | | 2 | Pulmonary embolism. | |
| | | 19 | | |

*Laparotomy: Excision of Portion of Intestine for Typhoid Ulcer by Lembert Suture.*

| Authority. | No. | Result. | Reference. |
|---|---|---|---|
| Morton ... | 1 | Recovered. | *Medical News, Phil.*, vol. li, p. 729. |
| Barlet ... | 1 | Died on 2nd day; opening not found. | |
| Kussmaul ... | 1 | Died; portion of gut excised and united. | |
| Martin ... | 1 | Died in 6 hours; ulcer stitched to parietes by Lembert suture. | |

From the statistics of enterostomy collected by Dr. B. Farquhar Curtis, of New York, occurring between the years 1873-87,[4] it appears that, of 62 cases of enterostomy for acute intestinal obstruction, 46, or 72 per cent., were relieved by the operation; 6 were not relieved (in 3 of these a fistula was formed below the obstruction); in the other 2 there is no definite statement whether relief was obtained or not.

Thirty-two cases recovered; in 19 the fæces resumed the natural passage *per anum* generally in a few days, 3 within twenty-four hours, 9 during the first week, and 4 during the second week; the longest record before resumption of passage of fæces *per anum* in these cases was ten weeks. The fistula closed spontaneously in 7 cases, and in 6 cases by operation.

Thirty cases died, showing a mortality of 48.3 per cent., thus:

| Cause of Death. | No. of Cases. |
|---|---|
| Sepsis of wound ... ... ... ... ... | 5 |
| Failure to reach the distended bowel ... ... | 3 |
| Gangrene of gut subsequent to operation ... ... | 4 |
| From shock ... ... ... ... ... | 4 |
| Bad condition of patient ... ... ... ... | 7 |
| Heart failure ... ... ... ... ... | 1 |
| Perforation of gut on the thirteenth day ... ... | 1 |
| Gangrene of gut existing at the time of operation ... | 1 |
| Extensive adhesions (infant) ... ... ... | 1 |
| Causes unknown ... ... ... ... ... | 3 |
| Total ... ... ... ... ... | 30 |

[4] *New York Medical Record*, 1888, vol. ii, pp. 8 and 233.

*Statistics of Cause of Death after Laparotomy for Acute Intestinal Obstruction.*[5]

| Cause of Death. | No. of Cases. |
|---|---|
| Sepsis due to gangrene of gut ... ... ... | 17 |
| Prolonged operation ... ... ... ... | 3 |
| Shock ... ... ... ... ... ... | 13 |
| Cause of obstruction overlooked or not found ... | 19 |
| Poor condition of patient ... ... ... | 101 |
| Complicated (peritonitis, gangrene, etc.) ... ... | 41 |
| Cause of obstruction irreducible ... ... ... | 9 |
| Unknown or wanting ... ... ... ... | 23 |
| Total ... ... ... ... ... | 226 |

*Statistics of Cases of Enterostomy with Artificial Anus.*[6]

| Result | No. of Cases. |
|---|---|
| Recovered ... ... ... ... ... | 11 |
| Died ... ... ... ... ... ... | 4 |
| Unrelieved ... ... ... ... ... | 1 |
| Total ... ... ... ... ... | 16 |

One other case died subsequently of delirium tremens.

The passage *per anum* was resumed in 7 cases, including the case just mentioned; the fistula closed spontaneously in 2 cases, and in 4 cases it was closed by operation.

## APPENDIX B.

DETAILS OF CASES OF INTESTINAL OBSTRUCTION CONDUCTED BY THE AUTHOR, WITH THE KIND ASSISTANCE OF MR. VICTOR HORSLEY AND DR. DOVE.—TWO CASES OF GASTRO-ENTEROSTOMY.

CASE I.—Successful. On June 11th, 1888. Rough-haired terrier, weight 15lbs., having been placed fully under the influence of ether, an incision was made in the middle line of the abdomen between the ensiform cartilage and umbilicus; two fingers of the left hand were introduced into the abdominal cavity through the wound, and a portion of the stomach withdrawn; this was held by an assistant, while, the fingers being again passed into the abdomen, a loop of intestine was drawn into the wound; this was done by pushing the omentum to the right and seizing a portion of the jejunum as near to its origin with the duodenum as possible. The portion of the stomach and intestine being now both outside of the wound, and supported by carbolised cotton-wool pads, a longitudinal incision about three-quarters of an inch in length was made through all the coats on the anterior wall of the stomach, about one inch from the greater curvature; a decalcified bone plate, prepared after Senn's method, with an opening in the centre three-quarters of an inch long by half an inch across, and armed with four chromicised catgut sutures, as already described, was slipped into the viscus through the opening, then the needles of the two lateral threads were passed through the entire coats of the stomach, close to the edge of the opening, the end threads being brought out through the incision. The threads were then given to an assistant to hold, while an incision was made in a longitudinal direction through the entire coats of the jejunum for three-quarters of an inch, another decalcified bone plate was then slipped into the intestine, and the lateral sutures passed through all its coats. The two plates were next approximated and held firmly in place by an assistant, and the corresponding threads of the opposing plates tied tightly, the lower lateral threads being tied first, then the end ones, and finally the upper lateral. The stomach and jejunum were then dropped into the abdominal cavity, the toilet of the omentum attended to, and the abdominal wound united by a few chromicised catgut sutures in the ordinary way. The operation was completed in twenty minutes. The dog on the next day was apparently perfectly well, and was fed on milk for the first two or three days, after which he had his ordinary diet. There were no bad symptoms, and the abdominal wound was perfectly healed by the first intention by the end of the week.

July 2nd. Three weeks after the operation the dog was killed with chloroform.

*Post-mortem.*—Wound perfectly healed, omentum firmly adhered to peritoneal surface of the wound; no trace of peritonitis; jejunum seen to be firmly adherent to stomach on its anterior wall; omentum also adherent to the junction of the two viscera.

[5] Collected by Dr. B. Farquhar Curtis, New York. *New York Medical Record*, 1888, vol. ii, pp. 8 and 234.

[6] Reported by Schebe and Fühe in *Münch. med. Wochensch.*, 1887, p. 856, and *Archiv klin. Chir.*, 1887, vol. xxxvi, p. 646.

No trace of the bone plates was found. On removal of the stomach and upper part of intestine from the body, I applied a ligature round the pylorus, and on pouring water into the œsophageal ends of the stomach, it at once passed freely through the gastro-jejunal opening into the intestine. The jejunal end was now tied firmly, the viscus filled with spirit, and the whole immersed in spirit.

CASE II.—Successful, June 18th. A dog, weighing 26 lbs., was placed fully under ether, and an incision between two and three inches long made in the middle line of the abdomen between the ensiform cartilage and umbilicus. The transverse colon and omentum were drawn out through the wound and turned up, the transverse meso-colon was next torn through for the length of an inch and a half; the posterior wall of the stomach was then brought through the opening in the meso-colon and the abdominal wound; a piece of jejunum, somewhat low down, was also withdrawn through the wound, and the two viscera supported with carbolised cotton-wool pads. An opening was made into the stomach and jejunum as in Case I, and decalcified bone plates introduced and firmly tied, as in that case. The parts were then dropped back into the cavity of the abdomen, the transverse colon replaced, and the toilet of the omentum attended to, and finally the abdominal wound was united in the usual way with chromicised catgut sutures. The operation lasted thirty minutes. The dog was quite brisk and well the following day. He was kept for three days on milk, after which he was fed on his usual food. The abdominal wound was perfectly healed on the 25th. He was killed with chloroform on July 16th, one month after the operation.

*Post-mortem.*—The omentum was as usual adherent to the abdominal wound, but not to the seat of juncture of the stomach and jejunum. The union between these, as you see, was perfect. There was no sign of peritonitis. No trace of the bone plates was to be found. On removing the stomach and portion of gut below the pylorus, water passed freely through the artificial opening. The viscus was subsequently filled with spirit and treated as the other.

### SIX CASES OF ILEO-JEJUNOSTOMY.

CASE I.—Successful. On June 25th a dog, weighing 32 lbs., was placed fully under the influence of an anæsthetic, and an incision about three inches in length was made in the middle line of the abdomen below the umbilicus; a portion of the ileum was then withdrawn, and some three or four inches of the intestine removed, also a wedge-shaped piece of the mesentery. The divided vessels were secured and tied with chromicised catgut. The two ends of the gut were each invaginated into itself for about one inch, and the serous surfaces stitched together with a continuous catgut suture passing through the serous and muscular coats only. The divided ends were now brought outside of the wound and supported by carbolised cotton-wool pads. An incision was next made in the convex surfaces of the two cut ends of intestine an inch and a half from the extremities and three-quarters of an inch long. Two decalcified bone plates, threaded as already described, and with an opening in the centre of each three-quarters of an inch long by half an inch wide were slipped through the openings into each portion of the gut, and the lateral threads passed through the whole of the coats of the intestines close to the edge of the opening, the end threads being brought through the wounds. The openings were then accurately applied to each other, the bone plates held firmly in position by an assistant, and the corresponding threads tied tightly. In this case I scarified the peritoneal surfaces between the plates with a needle. The intestine was dropped into the cavity of the abdomen, and the abdominal wound closed in the usual manner. The dog made a good recovery, and was killed fourteen days after the operation.

*Post-mortem.*—The omentum was firmly adherent to the wound and to the juncture of the intestine, union between the two portions of gut was perfect, and water flowed freely through the opening.

CASE II.—Successful. On July 6th a dog, weighing 15 lbs., was placed under an anæsthetic, and a similar incision to that of the last made. A portion of the ileum was removed some three inches in length, the ends invaginated into themselves, and fixed by a continuous catgut suture. An incision was made into the convex surface of each end, about an inch and a half from the extremities, and decalcified bone plates introduced into the intestines through the openings and fastened firmly as in last case. As the plates seemed to tilt a little, a Czerny-Lembert suture was inserted at each end, and the intestine was then dropped into the cavity of the abdomen, and the abdominal wound closed in the usual manner. This dog took his food well from the first, and passed fæces perfectly naturally; there never was any rise of temperature, and the abdominal wound was quite healed on the seventh day.

On July 20th, fourteen days after the operation, the dog was killed. The omentum was firmly adherent to the abdominal wound, and also around the wound in the intestine. The blind ends of the gut were firmly united. Dog had not lost flesh. Water passed freely through artificial opening.

CASE III.—Successful. On July 9th a dog, weighing 18 lbs., was put under an anæsthetic, and the ileum divided. This case was treated exactly in a similar manner as the last two. The animal took his food well from the first, and had no rise of temperature; passed fæces naturally.

July 27th he was killed. Omentum adherent to wound in parietes and at juncture of gut. On removing the portion of the intestine and pouring water through the proximal end, it flowed freely through the artificial opening.

CASE IV.—Successful. On July 26th a dog, weighing 18 lbs., was placed under an anæsthetic, and the usual incision made in the middle line below the umbilicus, the omentum pushed up, and the small intestine traced back to the duodenum. I then divided the gut, and removed some three or four inches, and endeavoured to perform enterorrhaphy by invagination, as I shall describe presently, but found it not practicable, as the mesentery here was so short; so I invaginated the two ends, and treated the case with decalcified bone plates as in the last cases. In this case I wrapped an omental flap round the whole, and stitched the portion of the omentum round by passing two stitches on at either end opposite the ends of the bone plates, which transfixed the two layers of omentum and mesentery, the stitches being placed parallel to the vessels. The dog never had a bad symptom or rise of temperature, and was killed on August 9th, fourteen days after the operation. The omentum was adherent to parietes, and the omental flap was firmly adherent round gut. Opening between the ends of gut perfect.

CASE V.—Successful. On July 27th, a dog, weighing 23 lbs., being anæsthetised, the usual incision was made in the middle line of the abdomen, a portion of the intestine withdrawn through the wound and a piece cut away. The ends were treated in the same manner as previously stated, and joined with decalcified bone plates. The dog made an uninterrupted recovery, and was killed on September 2nd, two months after the operation. The union between the two portions of gut was perfect, and a free passage existed from the one to the other by the artificial opening. No trace of the plates to be found. The dog had increased in weight.

CASE VI.—Died. On August 2nd a dog, weighing 15 lbs., being anæsthetised and the usual incision made, a portion of intestine was withdrawn and divided, and a piece removed, all bleeding points being ligatured. In this case I intended to perform enterorrhaphy by invagination, but owing to the smallness of the intestine I was prevented from doing so, and the bone plates had become spoilt, so I determined to invaginate the end of the distal portion into itself, and then implant the proximal end into the convex surface of the distal end in the following manner. I lined the proximal end with a thin piece of india-rubber, stitched the lower edge to the end of the intestine with a continuous catgut suture, and then with two long threads about eighteen inches long, armed at either end with an ordinary sewing needle, I passed one thread through the upper end of the india-rubber and all the coats of the intestine, passing a needle through on either side of the mesentery, and the other thread was passed through the india-rubber, and all the coats of intestine on the convex side of the gut equal distant from the first. A slit was next made on the convex side of the distal end, and the fine needle armed with the threads that had passed through the proximal end of the gut made to pass through the serous and muscular coats of the distal portion at either end of the slit. The threads were then drawn firmly, and the proximal end of the gut slipped into the opening below, and the fine threads tied firmly; a Czerny-Lembert stitch was inserted on either side to keep the lateral surfaces secure, and an omental graft was placed round the whole. The dog was very poorly for the next few days, and died on August 8th, six days after the operation. The abdominal wound was firmly united and the juncture of the intestine was likewise quite firm, but unfortunately a ligature had slipped from one of the vessels

in the omentum, and there was a quantity of blood in the abdominal cavity, accompanied by general peritonitis.

SEVEN CASES OF ENTERORRHAPHY BY INVAGINATION.

CASE I.—Died. On June 11th, a dog, weighing 15 lbs., was placed under an anæsthetic, and an incision made through the abdominal parietes, between two and three inches in length. A coil of small intestine was withdrawn through the wound, and about three inches removed with a V-shaped piece of the mesentery. All bleeding points were then ligatured. The upper portion of the intestine was lined with a thin band of india-rubber, half an inch wide, which was formed into a ring the size of the lining of the gut, by a few stitches of catgut. The lower end of the ring was then stitched to the end of the gut by a continuous catgut suture. Two catgut sutures 24 inches long, armed at each end with an ordinary sewing needle, was then passed through the india-rubber ring at its upper part and all the coats of the intestine. The posterior thread was passed one on either side of the juncture of the mesentery with the intestine, and the anterior thread at corresponding points on the convex portion of the gut. The posterior needles were next passed through the peritoneal and muscular coats only of the lower portion of intestine about half an inch from its cut edge, one on either side of the mesentery attachment. The anterior threads were similarly passed through the peritoneal and muscular coats of the convex portion of bowel. An assistant then made steady traction upon all the four threads, while the operator with a little manipulation invaginated the upper portion of intestine into the lower, care being taken to turn the edges of the lower end well into the intussuscipiens, thus bringing the serous surfaces of the two ends into close approximation for the distance of half an inch. The mesentery was not stitched. The gut, appearing to be firmly closed, was now dropped back into the abdominal cavity, and the parietal wound closed in the usual manner. Time of operation twenty minutes. The dog took his milk fairly well and passed fæces, on the following day; he however, was very poorly, and died on the 14th, three days after the operation.

*Post-mortem.*—Extensive general peritonitis, due to a leakage at the seat of operation at the mesenteric attachment. On tracing the intestine up it was found that through an accident the lower portion of bowel had been invaginated into the upper portion, thus the tendency of the peristaltic action of the bowel was to force the invaginated intestine out.

CASE II.—Died. On June 18th a dog, weighing 12 lbs., being anæsthetised, the usual incision was made, and a portion of intestine withdrawn through the wound. An attempt was made by Nothnagel's method to determine the upper from the lower. Sodium chloride was applied to the peritoneal surface, but there was no effect whatever produced beyond some contraction at the seat of application. I then traced the lower segment to the cæcum to be sure of not making the same mistake as in the last case. I then removed about three inches of intestine and a wedge-shaped piece of mesentery. The remaining steps of the operation were identical with those described in the last case, but there was great difficulty, owing apparently to the smallness of the bowel, to invaginate it; and I also thought it wise to introduce the Czerny-Lembert sutures, one on each side of the mesentery, and the divided mesentery was also stitched together. The intestine was dropped back into the abdomen, and the parietal wound closed in the usual way. The dog was apparently very well the next day, but on the day following he refused his food, and appeared poorly and died on the 21st, three days after the operation.

*Post-mortem.*—Abdominal wound healed, omentum adherent, sero-purulent fluid and general peritonitis present; intestine matted together: the cause of this was found to be a leakage, as in the previous case, at the juncture of the mesenteric portion of intestine.

CASE III.—Lived fourteen days. Omental flap. On June 20th a dog, weighing 20 lbs., being anæsthetised, an incision was made on the outer edge of the right rectus muscle for two inches. A piece of gut was withdrawn, and three inches removed, and the lower end traced to its insertion into the cæcum. The same difficulty was experienced here as in the last cases in invaginating the gut. This was, however, done after a little trouble, but the mesenteric side did not appear satisfactory, so I introduced another stitch through all the coats of the bowel, and the india-rubber ring from one side of the mesentery to the other; this was caught through the peritoneal and muscular coat of the lower portion and tied, making all secure. The cut edges of the mesentery were stitched together, and finally, to make matters more secure, an omental flap was wrapped round the seat of union, and fastened by a couple of stitches passing through the two folds of omentum and mesentery parallel to the vessels. The dog did very well, and took his food regularly until July 3rd, when he began to flag, and on July 5th, fifteen days after the operation, he died.

*Post-mortem.*—Parietal wound quite healed, omentum adherent to wound. Intestine seen to be distended down to seat of operation, and below this point the bowel was contracted and nearly empty. Omentum firmly adherent around invaginated portion; no leakage or peritonitis. On removing the portion of gut at the seat of operation, the upper part was found to be filled with hay, which the animal had eaten, and which formed a hard mass completely blocking the intestine. On removing this the lumen of the gut at operation was found to be quite patent, readily admitting the finger. The india-rubber ring had disappeared, and must have been passed *per anum*. This dog would undoubtedly have recovered had he not eaten his bed.

CASE IV.—Successful. On July 6th, a dog weighing 16 lbs. was anæsthetised, and the usual incision made; a knuckle of intestine was withdrawn, and Nothnagel's test applied to discover the upper from the lower portion of the bowel, with no result. The intestine was then traced down to the cæcum, and a piece of gut removed. The india-rubber ring was introduced and secured into the upper segment in the usual manner. I next, with four catgut sutures, one on either side of the mesentery and two on the convex surface of the bowel, stitched the two free borders of the intestine together, and by taking the upper portion lined with the ring between my right thumb and finger, and the lower portion between my left, I very easily invaginated the one portion into the other. I then passed four Czerny-Lembert sutures through the two parts, so as to prevent disinvagination; and finally, I cut a piece of omentum off and wrapped it round the seat of union, and fastened it in position with two sutures through the mesentery. There was not any bad symptom, and the dog made a perfectly good recovery, taking his food well and passing fæces in a normal manner. On July 21st, the dog was killed.

*Post-mortem.*—Abdominal wound quite healed, omentum adherent to wound. The omental graft was firmly adherent round juncture of gut, union between intestine perfect. On removal of portion of bowel operated on, water was found to have passed readily through. The india-rubber ring had disappeared, and the finger passed freely through seat of juncture, where there was felt to be a slight constriction.

CASE V.—Successful. July 16th. A dog; weight 20 lbs. The usual median incision was made, and a piece of small intestine withdrawn; an end was traced to its insertion into the cæcum. Two inches of intestine were removed, the upper end lined with india-rubber ring, and the edges of two cut ends of intestine fastened by four catgut stitches, as in the last case, and the upper end slipped fairly easily into the lower; then two Czerny-Lembert sutures were inserted on each side of the mesentery and one on the convex surface to prevent disinvagination. No omental flap or graft was used. The intestine was dropped back into the cavity of the abdomen, and the parietal wound closed. The dog made a perfectly good recovery, and was killed on August 9th, three weeks after the operation. The omentum was, as is invariably the case, firmly united to the abdominal wound. There was no peritonitis, and the union at the seat of operation was found to be perfect. Water passed freely through gut.

CASE VI.—Successful. July 27th. A dog; weight 18 lbs. The usual incision being made and a piece of intestine removed and the lower end traced to its insertion into the cæcum, I, instead of lining the upper portion of gut with india-rubber, formed a ring of round india-rubber slightly smaller than the lumen of the gut. I then stitched this with a continuous catgut suture to the upper portion of the bowel. I next fastened with continuous suture another ring, slightly larger than the first, into the lower portion of bowel, wrapping it completely round with the coats of intestine. I then slipped the upper into the lower, and introduced two Czerny-Lembert sutures at the mesenteric side, fastened on an omental flap round the seat of union and dropped it back into cavity, and united the abdominal wound. The dog recovered perfectly from the operation, and I killed him on September 28th, two months after the operation. He had lost a considerable amount of flesh, and did not feed well.

*Post-mortem.*—Wound in parietes firmly united. Intestine

above the seat of operation much distended and below somewhat contracted. A hard mass was discovered in the upper part, which on examination proved to be a mass of hay which he had eaten. On removal of this the lumen of the gut was found to be perfect. There was no trace of the rubber ring. The finger passed freely through the opening.

CASE VII.—Successful. August 10th. Dog weighing 27 lbs. After the usual preliminaries a portion of intestine was withdrawn through the wound and a piece removed. The upper end was lined with india-rubber, and the operation performed in the same way as in Cases IV and V. The dog had no bad symptom. On November 26th, three months after the operation, the dog was killed in the usual manner. The union of the intestine was perfect, and it is not easy to distinguish the site of the operation. The dog had gained 2 lbs. in weight since the time he was operated on.

THREE CASES OF ILEO-COLOSTOMY (ALL SUCCESSFUL).

CASE I.—Successful. July 9th. A dog weighing 13 lbs. Incision made in middle line below the umbilicus. The cæcum was drawn out through the wound, and the ileum divided about three inches from the ileo-cæcal valve. The distal end was invaginated into itself, and fixed by a continuous catgut suture. The peritoneal end of the gut was lined with a thin piece of india-rubber in a similar manner to that described for enterorrhaphy. Two threads of catgut, some 24 inches long, each thread being armed with two needles, were used. The posterior thread was passed through all the coats of the intestines, one thread on either side of the mesentery, and the other thread was passed through the opposite convex surface of the intestine in two places; these threads were then given to an assistant to hold, while a longitudinal incision was made on the convex surface of the ascending colon. The sutures connected with the ileum were then passed through the serous and muscular coats of the ascending colon at either end of the opening. The mesenteric sutures at the lower and the anterior threads into the upper were about an inch apart, and half-an-inch from the extremities of the incision; the ileum was then pushed into the slot, and the ligatures tied securely at either end. A Czerny-Lembert stitch was inserted on one side where the edge did not appear to be closely approximated. The dog had not the least inconvenience from the operation, and had thriven up to the time he was killed. On November 26th, twenty weeks after the operation, the dog was killed. He had gained 4 lbs. in weight since the operation. The union of the ileum with the ascending colon at the seat of operation was perfect, and allowed a full stream of water to pass. [The specimen was shown.]

CASE II.—Successful. July 16th. Dog weighing 20 lbs. Operation performed exactly in the same manner as last, excepting that the abdominal incision was made outside of the rectus muscle on the right side. The dog made an uninterrupted recovery, and was killed eighteen days after operation.

CASE III.—Successful. July 26th. Dog weighing 18 lbs. Abdomen opened by median incision; all other steps of the operation the same as in last two cases. The dog was killed three weeks after operation.

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# REPORT ON AN INQUIRY INTO THE ETIOLOGY OF SUMMER DIARRHŒA.

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THIS inquiry into the etiology of summer diarrhœa had its origin in the excessive infantile mortality which occurs annually from it in Leicester, this town suffering more than any other community in England.

It is scarcely necessary to consider here the objections that have been raised to the term diarrhœa as denoting any one definite disease. Undoubtedly diarrhœa exists as a symptom in many diseases, and deaths from "diarrhœa" are the results of probably very varying pathological conditions. But after making due allowance for all these, there undoubtedly does exist a specific disease prevalent during the summer weather, in which one of the most marked and obvious symptoms is an excessive watery, offensive, discharge from the intestinal canal.

Many observers have previously turned their attention to the causes at work in Leicester in producing this ailment, but without getting much beyond the fact that, in some way or other, the heat of the sun was the important factor in its production, but the exact manner in which an increase of temperature brought about the disease has been matter of much dispute.

It has been argued that improper feeding, maternal neglect from mothers being at work, teething, density of population, damp subsoil, sewer emanations, etc., were factors in the production of the disease, but it is easy to show that many of these causes affect infants only, whilst the disease attacks persons of all ages. Out of 24,157 cases of which I have record during the past four years 16,506 were over 10 years of age; whilst only 1,219 were under 1 year of age. Yet when we turn to the *deaths* occasioned by the disease in Leicester, during the above period, we find that out of a total mortality of 837, no fewer than 725 were infants under 1 year. These figures should once for all dispel the popular impression that the disease *is chiefly confined to infants and young children.* The *mortality* is almost entirely confined to them, but persons of all ages, occupations, and position suffer, though happily with non-fatal results. Again, many of the *alleged causes* are in action the whole year round, but the disease prevails only for a very limited period. Many of these, such as density of population, damp subsoil, the employment of mothers in factories, etc., exist to an equal extent in other towns and places where the same excess of diarrhœa is not met with.

After arranging and analysing a large amount of statistical and other information at my disposal, two important facts were soon apparent: first, that prior to 1850 Leicester showed no such excess of diarrhœa mortality as at the present day, but since that date the disease has apparently been steadily, and uninterruptedly on the increase; secondly, and of considerable importance, the prevalence of the disease at the present time is very largely in excess in certain districts of the borough, and comparatively absent in other parts.

Old Leicester lies low down in the valley of the Soar, but with the increase in population of the last twenty years it has gradually extended itself on either side of the river to the adjoining higher districts. Speaking generally, the town is situate upon clay, beneath which is the new red sandstone, but, following the bed of the river, stretching out for a variable distance on either side, alluvial deposit is found, consisting of sand, gravel, etc., of varying thickness. Overlying all these is, of course, a variable amount of soil or common mould.

Now the district where diarrhœa most prevails is the low-lying one following the river, and which consists also of all the older parts of the town; this, for convenience, I shall speak of as the "diarrhœa area." I have already pointed out that within this area persons of *all ages, stations, and occupations* are attacked, and one is immediately led to ask, What agency is there at work in this diarrhœa area, which apparently is much less active in other districts of the town? The cause must be one which is common to all the dwellers there, and must therefore apparently be either in the food, the water, or the air. The food and water supplies are practically the same throughout the borough, and I therefore naturally turned my attention to an examination of the air in the various districts. Previous observers in Leicester had already suspected a contaminated air to be connected with the causation of the disease, and further presumptive evidence was afforded me from the fact that during the summer of 1885 and 1886 large numbers of children were under my care at the Borough Hospital, situate on a slightly elevated site about a mile from the centre of the town, and yet, though most of these children came from the "diarrhœa area" and the temperature practically the same at the hospital as in the town, no diarrhœa occurred amongst them.

In examining the air of the various parts of the town, I set before myself the task first to ascertain approximately the number of microbes or their germs which existed therein prior to the onset of the disease and during the time when the disease was at its height, using for this purpose Hesse's apparatus, with sterilised nutrient gelatine. The details of the working of this are now so well known to bacteriologists that there is no need to describe the operations in minute detail. There are, no doubt, certain objections to be made to this method, but if used in the same manner and under the same conditions, the results obtained from it are reliable and comparable the one with the other. The nutrient gelatine used was neutral or with the faintest trace of an acid reaction.

The results obtained show that at the time when the disease is prevalent the atmosphere contains at least double or treble the

number of microbes or their spores compared with periods before or after the epidemic, when the aërial temperature is much lower. Further, in the diarrhœa area of the town *they were fourfold as numerous* as in those districts of the borough where the disease does not prevail. Thus it ranged from 6,000 to 7,000 per cubic mètre in the former, whilst not more than from 600 to 1,400 existed in the latter. But, further, in their growth and multiplication in the nutrient media the liquefaction of the gelatine was more rapid and complete, and a much more offensive odour was produced by the organisms obtained from the "diarrhœa area" than with those from other districts.

During the summer of 1888, which was notable for its absence of sunshine and continuous rainfall, the disease prevailed to a much less degree than in the two preceding summers, and the number of organisms found to be present were correspondingly smaller in number.

Secondary cultivations made from the original growths into test tubes of nutrient gelatine grew and developed in the manner depicted in the accompanying figures. A needle charged from the primary growth was inserted to about an inch, and the tubes maintained at a temperature of about 65° F. On the second day the needle track was distinctly visible; on the fourth day a small white patch had developed, as seen in Fig. b. On the sixth day this had extended, and the gelatine was becoming liquefied in a cup-shaped manner, as seen at Fig. c. On the eighth day this process had extended, as at Fig. d; whilst on the twelfth day the whole of the gelatine to the depth of the original insertion of the needle was liquefied, as at Fig. e.

Fig. b.

Fig. c.

During the summer of 1888, in addition to the cultivations from Hesse's tubes, I made a series of plate cultivations by simply exposing plates of glass, covered with nutrient gelatine, to the air for ten minutes each, and then keeping them in moist chambers at the same temperature as the above. The results obtained agreed approximately with the other observations. In the "diarrhœa area" a much larger crop of growths was obtained than in the non-diarrhœa localities, and they again developed a much stronger and more offensive odour as the result of their growth.

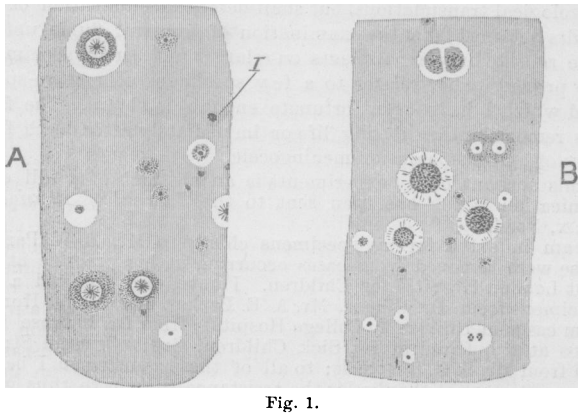


Fig. 1.

The accompanying drawing (Fig. 1) shows some of these growths on plates; the gelatine of the patch A was faintly alkaline, that of B was faintly acid before use. Of course, after-growths had taken place on them, both were strongly alkaline.

A point in connection with these plate cultivations is worth noting. During the summer of 1888 I observed a number of growths of a bright red colour, such as shown at 1 on the gelatine A.

Microscopic examination showed these to be large micrococci, of which Fig. 3 is reproduced from a photograph. It appears to be micrococcus prodigiosus, and possibly of no pathological significance, but the point I wish to bring out is that, in former years, I have not met with this particular organism in such abundance as last summer, a fact which would seem to indicate that different bacteria, like vegetables of larger growth, have their seasonal prevalences, though at present we know but little as to the conditions which are especially favourable to individual varieties.

In addition to examination of the air, I have, during last summer, subjected the soil of the various districts of the town to a bacteriological examination, the method adopted being as follows: A small quantity of the earth to be examined was dried at a gentle heat in a water bath and triturated to a fine powder; of this, half a gramme was shaken up with five cubic centimètres of sterilised distilled water, and ten drops of the mixture added in a test tube to liquified nutrient gelatine. This was then poured out upon glass plates, and growths and cultivations obtained therefrom in the usual manner. The samples of soil were taken at

Fig. d.

Fig. e.

various depths varying from six inches to six feet below the surface. In all those places where the earth was taken from the older parts of the town, and within the "diarrhœa area," the growths were from three to six times as numerous as in those samples of earth taken in the higher and newer districts of the town. Especially was this the case where the earth was evidently polluted by leakage from defective sewers into the surrounding soil, a condition which obtains largely in the old parts of the town. Further, as in the case of the cultivations obtained from aërial microbes, in these polluted soils the liquefaction of the gelatine was more rapid, more complete, and developed a much stronger and offensive odour than was the case with the other soils.

I have endeavoured during the course of my observations to obtain some corroborative evidence as to the bacteriological origin of this disease from the bodies of those suffering from it, but the few results I have obtained are unsatisfactory. In the first place, it is with the utmost difficulty that I have been able in three or four instances to obtain permission to make a *post-mortem* examination in a sufficiently short time after death to be of any service in this respect; for, occurring as these deaths do in the very hottest season of the year, unless the examination be made within a very few hours of death, it is useless for any bacteriological purposes. In three cases I examined the bodies within six hours of death, and in each of these obtained an abundant cultivation from the kidneys; in two cases growths were obtained from the spleen and mesenteric glands. I made also abundant cultivations from the contents of the intestinal canal,

but which, in our present knowledge, or want of knowledge, of the bacteria contained therein under normal conditions, are not of much value.

In the growths obtained from the kidneys, as well as those from the intestines, the liquefaction of the gelatine was more rapid and the odour developed much stronger than in those from the spleen and glands. In each case swarms of micrococci and bacilli were present, of various sizes.

One important fact may here be alluded to: that in all those cultivations, whether from the air, the soil, or the body, where the gelatine was rapidly liquefied with a disagreeable odour, a very small dose sufficed to bring on in the adult subject a sharp attack of diarrhœa, lasting some hours.

One other observation of some importance was made during the past summer, that is, the cultivation of one or more of these bacteria in milk. I conducted two sets of experiments with this important article of food; in the first I merely sterilised the milk, and added just sufficient pure gelatine to solidify it, and then made test tube cultivations in the usual manner. In the other I used only the whey of the milk, the curds being abstracted therefrom; the whey was added to nutrient gelatine. In both cases the bacteria obtained from the primary cultivations of both the air and the soil of the diarrhœa districts grew and multiplied almost as well as in the pure nutrient gelatine itself, proving that milk is a favourable soil for their growth and development.

Having thus so far arrived at conclusions which point strongly to the presence of one or more forms of microbic life as being concerned in the production of diarrhœa, one has still to adduce reasons why Leicester should suffer so much above all other towns.

Prior to 1850 diarrhœa does not appear to have been unduly prevalent here, but since that time the mortality has steadily and continually increased. By references to past records of the sanitary condition of the town, it is amply proved that since that time the soil of the town, especially in the older parts, has been undergoing a constant pollution with organic filth from insufficient and defective sewers, which, even up to the present day, are polluting the ground in which they are laid. A new scheme, however, involving a large expenditure, is now being carried out in the borough, the old privies and cesspits also, which formerly existed in the town in large numbers, are now almost all abolished. Until very recently, too, the low lying parts of the borough were subject to periodical floodings by overflow from the river, itself not too clean, from all of which causes the soil of the older and lower parts of the borough has been more or less polluted with organic filth. Given the condition of the earth, *plus* the heat from the rays of the summer sun, and we find ample explanation for the coming into existence of vast numbers of microbes and their germs.

Many of the observers alluded to above as having studied this problem had directed their attention to meteorological conditions in connection with the disease, and as before stated, had shown, that whatever other causes might be at work, a high temperature was the one *sine quâ non*, without which it did not exist; and in those summers when the temperature was below the average, then diarrhœa was also below the average. Most of the actual observations made upon the temperature referred, however, chiefly to *the temperature of the air*. During the last three years, I have in additon recorded twice daily, at 9 A.M. and 3 P.M., the temperature of the earth at depths of one foot and four feet, during the months of June, July, August, September, and October, and these observations bring out very clearly the fact, that not until the earth at the depth *of one foot has reached about* 60° *F., or some four degrees less than this at four feet* deep, does diarrhœa begin to prevail in Leicester to any marked degree. Last year it was not until August that diarrhœa really began to prevail, and not till then did the one-foot thermometer register continuously 60° of heat in the earth, or some 56° or 57° at four feet from the surface. In some preceding years this degree of heat in the soil has been reached early in July, and the epidemic has burst out at a correspondingly early period.

Whether the geological formation of the district on which Leicester is built has any influence in intensifying the incidence of the disease I am not in a position to say, but I am strongly of opinion that its geographical position is an important factor. Lying in the hollow of a valley, which runs north and south, the low-lying districts of the town scarcely feel whatever slight breezes may exist during the sultry heat of midsummer, and the air in the confined streets of these districts tends to become stagnant. To this also, as a factor of considerable importance, must be added the habits of the people. The population is composed largely of artizan and "factory hands," a large amount of female labour is employed, and, as in other manufacturing towns, much crass ignorance and carelessness prevails in the proper management and feeding of infants and young children. This, together with early marriages, tends to produce a large proportion of weakly, ill-nourished infants, amongst whom the *bulk of the fatal cases occur*.

I have purposely avoided saying anything as to the particular bacteria probably concerned in producing the disease, because at present I have not sufficient evidence to warrant me in making any positive statement thereon. In all the growths hitherto obtained micrococci of various sizes, together with a number of small bacilli, have been present. In those cultivations which most quickly liquefied the nutrient material in their growth, and where the more offensive odour was generated, these latter existed in largest numbers. Secondary and purer cultivations from these induced diarrhœa within six hours after being swallowed. In Fig. 2 (which is produced from a photograph) the small bacilli are shown.

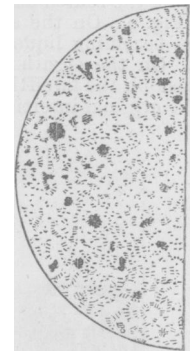

Fig. 2.

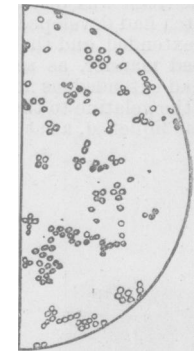

Fig. 3.

Again, a wide field of research opens itself out as to whether this or any other micro-organism be the direct cause of the disease, or whether, as is most likely the case, it be not due to something in the nature of an alkaloid or ptomaine, produced by the growth and development of the microbe in the material, wherever it may be, which furnishes it with pabulum and nourishment.

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## REPORT ON CEREBRO-SPINAL FLUID.

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(From the Physiological Laboratory, University College, London.)

I am indebted to the Scientific Grants Committee of the British Medical Association for assistance in defraying the expenses involved in my work. I have examined a large number of various pathological transudations, but shall defer the publication of the results obtained from the examination of dropsical fluids until I have repeated my experiments on a larger number of specimens. The present paper relates to a few specimens of cerebro-spinal fluid which I have been fortunate enough to obtain. The fluid was removed either during life or immediately after death from cases of hydrocephalus or meningocele.

This account of my experiments is an abstract of a full communication which has been sent to the *Journal of Physiology*, vol. x, No. 4.

I am indebted for my specimens chiefly to Mr. R. W. Parker, these were removed from cases occurring in his practice at the East London Hospital for Children. I have also received a few specimens from Dr. Ringer, Mr. A. E. Barker, and Mr. V. Horsley from cases in University College Hospital; from Dr. Penrose from cases at the Hospital for Sick Children, Great Ormond Street, and from Mr. S. G. Shattock; to all of these gentlemen I beg to offer my sincerest thanks for the assistance they have thus given me.

The fluid is clear and colourless, faintly alkaline, and of low specific gravity (1006 to 1008). The first specimens I examined were from cases of spina bifida; they were examined some years ago, and the results published in the report of the Spina Bifida Committee.[1] I, however, insert them here.

| | Case I. | Case II. 1st Tapping. | Case III. 4th Tapping. |
|---|---|---|---|
| Water in parts per 1,000 ... | 989.75 | 919.877 | 991.658 |
| Solids ... ... ... ... | 10.25 | 10.123 | 8.342 |
| Proteids ... ... ... | 0.842 | 1.602 | 0.199 |
| Reducing substance (reckoned as dextrose) ... ... ... | 0.002 | Traces | 0.165 |
| Extractives ... ... ... | 9.624 | 0.631 | 2.865 |
| Salts ... ... ... ... | | 7.890 | 5.115 |

The general results here obtained agree very well with analyses previously published.[2] Tabular statements of this kind, however, do not show anything characteristic of the fluid examined; they show (1) a very small percentage of proteids, (2) a proportion of inorganic salts approximately equal to that in the blood, lymph, and transudations generally, (3) a small proportion of a substance which reduces alkaline solutions of copper salts like sugar. But all these characteristics might be equally well possessed by a dilute transudation, such as occurs in œdema of the subcutaneous tissues. The peculiarity of cerebro-spinal fluid lies in the quality, not the quantity, of proteids that are present, and in the fact that the reducing substance present is not sugar, but something else.

*The Proteids.*—Of previous investigators, Hoppe-Seyler is the only one who recognises that there is something peculiar about the proteids present; he says that boiling gives a cloudiness only, because the quantity of proteid is small and the liquid is alkaline. There is nothing peculiar about that; a weak alkaline solution of any albumin or globulin does not give a flocculent precipitate on heating until it is rendered faintly acid. Hoppe-Seyler then goes on to say that although he had at one time considered that the proteid present was of the nature of casein, later investigation had led him to believe that it was a globulin. He further states that fibrinogen is absent; there is no coagulum on heating to 56° C., and no formation of fibrin on admixture with serum. This is, so far as I can find, the only trustworthy statement previously made with regard to the nature of the proteids.

Let me now give a summary of the investigations, so far as they relate to the proteids, which I have made.

| Case. | Quantity of Proteid. | Kind of Proteids Present. |
|---|---|---|
| 1. S. B.[3] | 0.0842 per cent. | Globulin; albumose of doubtful variety. |
| 2. S. B. | 0.1602 ,, | Not investigated. |
| 3. S. B. | 0.0199 ,, | Globulin. |
| 4. S. B. | — | Globulin; proto-albumose; deutero-albumose. |
| 5.[4] | — | Albumose present; other reactions doubtful (mucin absent). |
| 7. H.[3] | 0.65 | Fibrinogen; serum globulin; serum albumin; proto-albumose (acute case). |
| 8.[5] | — | Globulin; proto-albumose. |
| 9. S. B. | — | — |
| 1st tapping | — | Globulin; albumin; proto-albumose. |
| 2nd ,, | Proteids more abundant than in first tapping | ,, ,, ,, |
| 10. H.[3] | — | Globulin; proto-albumose; peptone. |
| 11. S. B. | — | Globulin. |
| 12. H.[3] | — | — |
| 1st aspiration | 0.045 | Globulin (traces); proto-albumose. |
| 2nd ,, | 0.069 | Globulin; proto-albumose. |
| 3rd ,, | 0.272 | Globulin; albumin; proto-albumose (traces). |
| 13. H.[3] | — | Globulin; proto-albumose; peptone (traces). |

In two cases the proteid present consisted wholly of globulin. In six cases, the proteids consisted of globulin and albumose. The albumose present was generally proto-albumose; in one case deutero-albumose was present also; in two cases peptone was present in addition to albumoses, that is true peptone in Kühne's sense—a proteid which is not precipitable by saturation with ammonium sulphate. In three cases albumin was present, but two of the three cases may be excluded from the general classification; Case 7 was a case of acute inflammation, and in Case 12 (third tapping) there was also doubtless a chronic or subacute inflammatory condition; that leaves us with Case 9 as the only instance in which apparently normal cerebro-spinal fluid contained albumin.

Fibrinogen was absent throughout (except in Case 7, which, as before mentioned, was not an instance of the normal fluid, but is useful for the sake of contrast with the normal fluid). Addition of cerebro-spinal fluid to serum never caused the formation of fibrin; heating the cerebro-spinal fluid to 56° C. also caused no precipitate. The globulin present is one which, like serum globulin, is coagulated at a temperature of 75° C. It is not cell globulin,[6] as when tested with dilute magnesium sulphate plasma it has none of the properties of fibrin ferment.

The interest, however, of the proteids seems to me to be the presence of albumoses and peptones; on investigating the question as to whether the fluid contains any digestive ferment to produce these, the experiments I have performed gave in all cases a negative result.

Peptone has from time to time been described as a normal constituent of blood, milk, pus, and other fluids and tissues of the body. As Neumeister[7] has recently pointed out, such observations were made previous to the discovery of the use of ammonium sulphate as a means of separating peptones from other proteids, and are therefore untrustworthy. He also considers it possible that in the heat coagulation of albumins and globulins, a small amount of primary albumoses (that is proto- and hetero-albumose) may be formed by the hydrating action of the acidified hot water. This action must, however, be very small when the acidification is so slight, and the heating is prolonged for so short a time (two or three minutes) as it was in my experiments. I, however, in several cases obtained evidence of albumoses in the original fluid and, in Case 12, separated the albumoses from other proteids by the use of alcohol; alcohol precipitates all the varieties of proteid present, and its prolonged action coagulates (that is, renders subsequently insoluble in water) the globulin, and leaves the albumoses still freely soluble.

I tested the question as to the presence of albumoses in other fluids, by first filtering off the proteids coagulable by acidulation and boiling, and then testing for albumoses by the nitric acid and biuret reactions. In this way I examined seven specimens of blood (man, horse, sheep, and rabbit), two specimens of pericardial fluid (horse), one specimen of pleuritic fluid, four of ascitic fluid, four of fluid removed from blisters, and three of hydrocele fluid. As a rule the filtrate gave a faint xanthoproteic reaction; in a few cases there was not sufficient proteid to give even that; but in all cases albumoses were absent.

*Reducing Substance.*—The existence of a reducing substance in cerebro-spinal fluid has long been known. Claude Bernard[8] spoke of it as sugar. Bussy and Deschamps[9] found a reducing substance in the normal cerebro-spinal fluid of the horse and dog, as well as in a specimen obtained from the ear of a man who had sustained a fracture of the base of the cranium. In none of their experiments, however, were they able to induce the alcoholic fermentation. The idea that the substance in question was not sugar, but something else, did not strike them; and it was Turner[10] (who examined the fluid removed from a case of spina bifida by Sir James Paget) who made the suggestion that probably it was not a carbohydrate at all, but some derivative of albumin that possessed the reducing action.

Since that time the existence of a reducing substance in cerebro-spinal fluid has been a matter of common observation. In addition to not undergoing the alcoholic fermentation, the fact has also been observed that it has no action on the plane of polarised light. This negative evidence I have been able to confirm, and to add to it the additional point that it does not give the phenyl-hydrazine test for sugar.[11]

Gorup-Besanez[12] suggested that the substance was the same as Bodeker's alcapton,[13] a statement to which my attention was first drawn by a paper by G. Thiéry;[14] but I am not aware that this supposition has ever before been put to the test of experiment. Alcapton was the name given by Bodeker to a reducing substance

[1] *Clinical Society's Transactions*, 1885.
[2] See Hoppe-Seyler's *Physiol. Chem.*, p. 601.
[3] S. B. means spina bifida. H. means hydrocephalus.
[4] Case of myxœdema.
[5] Case of cerebral meningocele.
[6] See my paper on the Nature of Fibrin Ferment, *Journal of Physiol.*, vol. ix, p. 229.
[7] Neumeister, *Zeits. f. Biol.*, vol. xxiv, p. 272.
[8] Quoted by Gorup-Besanez, *Lehrbuch*, vol. ii, p. 397.
[9] *Bulletin de l'Académie de Médecine*, December, 1852.
[10] *Royal Society Proceedings*, vol. vii (1854), p. 89.
[11] A fact which also excludes glucosamine, a nitrogenous reducing substance (see F. Tiemann, *Berichte d. Berlin. Chem. Gesellschaft*, vol. xix, p. 49). Glycuronic acid is excluded by several reactions.
[12] *Loc cit.*
[13] *Zeitschr. f. rat. Med.*, vol. vii, p. 128.
[14] Thiéry, *Progrès Médical*, vol. xiv, p. 283.

occasionally occurring in urine, and which has since been shown to consist of pyrocatechin or allied aromatic substances. The observations which I have made in two cases (7 and 12) have convinced me that the substance is pyrocatechin; though whether this substance is present free, or in some combined condition, I am unable to say.

Hoppe-Seyler states that the reducing substance (which he speaks of as sugar) is not a normal constituent of cerebro-spinal fluid, but only appears subsequent to the irritation set up by tapping. In my own work I have never failed to find the reducing substance; its quantity, however, is very much increased by repeated tapping or aspiration. The fluid removed by the first operation may require to be concentrated before it gives the test in question.

*Salts.*—C. Schmidt made several analyses of hydrocephalus fluid, and remarked on the high percentage of potassium salts present. Hoppe-Seyler quotes three analyses.[15]

In two out of the three cases there is certainly a high percentage of potassium salts. Subsequent investigations have, however, shown that this is quite exceptional; the following are a few analyses that I have been able to find:

Lassaigne[16] gives the following numbers: In fluid removed from an old woman, the total quantity of salts in parts per 1,000 was 8.54, of which 8.01 consisted of sodium chloride; in the cerebro-spinal fluid of the horse he found total salts per 1,000 6.89, of which 6.10 consisted of sodium chloride.

Yvon[17] examined the fluid from a case of hydrocephalus, and found total salts per 1,000 8.90, of which 7.098 consisted of sodium chloride.

Fr. Müller's[18] case was also one of hydrocephalus; he found the total salts per 1,000 to be 8.80; and the ratio NaCl : KCl = 21.5 : 1.

In the one case (Case 13) in which I have investigated this question, the ratio of the two salts was nearly the same as in Müller's case, namely, NaCl : KCl = 95.15 : 4.85, and I would specially draw attention to two points in the method adopted: (1) that a large quantity of liquid, 300 cubic centimètres, was taken, and thus errors due to manipulation were minimised; (2) organic matter was destroyed, not by ignition, but by means of fuming nitric acid; by this means the passing off of volatile salts, like sodium chloride, was entirely prevented. Ignition was employed in a later stage to destroy the last traces of organic matter; but it is when incineration is performed in the presence of a larger quantity of carbonaceous matter that the danger of salts like sodium chloride being carried off is especially to be feared. As regards the saline constituents, it can therefore be said that there is no peculiarity in cerebro-spinal fluid. It is in the exceptional character of the proteids, and in the presence of pyrocatechin, that this fluid stands clearly marked off from serous or lymph-like fluids, and would be more correctly classified with secretions.

[15] *Physiol. Chemie*, p. 604.
[16] Quoted by Thiéry.
[17] Yvon, *Journ. de Pharm. et de Chimie*, série iv, vol. xxvi, p. 240.
[18] Müller, *Mittheil. a. d. Würzburger med. Klinik*, vol. i, p. 267.

## REPORT ON PROTEID POISONS, WITH SPECIAL REFERENCE TO THAT OF THE JEQUIRITY (ABRUS PRECATORIUS).

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It is only within the last thirty years that the fact has been established that a proteid, when introduced into the circulation of the blood, is poisonous. This fact, remarkable as it is in itself, becomes of greater significance when it is considered that these poisonous proteids are not distinguishable by any well-marked chemical reactions from the non-poisonous proteids, and that proteids are not only essential as food to animals, but also have an important nutritive relation to protoplasmic cell-life both in the animal and vegetable kingdoms. During the last two years I have been engaged, as British Medical Association Research Scholar, in the investigation of the properties and action of certain of these proteid poisons. Those that have specially occupied my attention are the jequirity (abrus precatorius), the papaw juice (papain), and the animal albumoses and peptones.

The list of the proteid poisons is extending more and more, and may be subdivided into two groups—those found in animals and those found in plants.

*Animal Proteid Poisons.*—1. First and foremost stands the *venom of snakes*, both colubrine and viperine; 2. The *serum of the eel*—the conger eel and the muræna; 3. Poisons formed during natural digestion in the stomach and small intestines—*albumoses and peptones*; 4. Proteid poisons found in certain spiders. To these may be added the body, which produces coagulation of the blood *intra vitam* (Wooldridge).

*The Vegetable Proteid Poisons.*—5. Jequirity (abrus precatorius); 6. Papain (carica papaya); 7. Lupinotoxin (?) (lupinus luteus).

*The Poison of Jequirity* (abrus precatorius).—The seeds of jequirity contain a substance which, as is well known, when extracted as in a watery infusion, produces a local irritation and inflammation of the conjunctiva, which has been utilised in practical medicine for the cure of granular lids and of pannus. Its employment in these conditions has not, however, been found to be so beneficial as at one time was thought probable, so that at the present time jequirity may be said to possess chiefly a scientific interest—one, as I shall indicate, of possibly great significance. Investigations into the exact nature of the poison have not been wanting, and the knowledge obtained from them has gone through many curious phases.

From the researches of Sattler, Cornil, and Berlioz, it was concluded that the irritant action of jequirity was due to a special bacillus which grew in the infusion of the seeds, and was called the jequirity bacillus. Contrary, however, to the behaviour of liquids containing specific bacteria, the physiological activity of the infusion of abrus seed was totally destroyed by heating it to the boiling point of water (Klein); and, following this result, Warden and Waddell[1] separated from the seed a body they called "abrin," which was a proteid body, and which possessed the physiological properties of jequirity. Furthermore, although these observers found bacteria in the local lesions produced by jequirity, these organisms were of various kinds, and, after cultivation and separation, were found to have none of the poisonous properties of jequirity. To dispose at once of this idea of the bacterial nature of jequirity poison, I may say that in my experiments, using a pure product, I have found no bacteria present in the local lesions, either in those produced at the seat of injection or in those produced internally in the peritoneum or alimentary canal. The sections were stained by Gram's method.

We must look, therefore, to the proteid or proteids present in the seed for the poison of jequirity. Warden and Waddell's "abrin," as described by them, did not possess very definite characteristics; it was called a vegetable "albumin," but evidently did not belong to this class, as it was precipitated by acetic acid. In 1886, I separated and examined the proteids present in the seeds, and obtained the following results[2]—both of the proteids separated possessing poisonous properties.

*Nature of Jequirity Poison.*—The seeds contain two proteids—a globulin and an albumose. The globulin is soluble in 15 per cent. sodium chloride solution, and coagulates by heat between 75° and 80° C. Like other members of its class, it is precipitated from solution by saturation with sodium chloride and magnesium sulphate. It belongs to what I have described elsewhere as the vegetable paraglobulins.[3] The albumose is soluble in water, is not precipitated by boiling, but is thrown down by nitric acid, the precipitate being soluble on heating the solution, and coming down again on subsequent cooling, this being the characteristic reaction of the albumose class. This body also gives the "peptone" reaction, namely, a pink coloration with copper sulphate and caustic potash.

For the investigation of the physiological action of these two proteids, the mode of separation from the seed is important, because, as I shall discuss subsequently, it is a question whether these proteids are of themselves poisonous, or produce their toxic effects by having a non-proteid body, as it were, tacked on to them—in fact a body, possibly alkaloidal in nature, not completely separated from the proteid in the preparation of the pure poison.

The globulin is separated by extracting the crushed and decorticated seed with 15 per cent. sodium chloride solution, and precipitating the clear filtrate by saturation with solid sodium chloride after acidulating with acetic acid. The precipitate of globulin with part of the albumose is mixed with distilled water, and dialysed in running water for several days. The globulin is in

[1] *The Non-Bacillar Nature of Abrus Poison*, Calcutta, 1884.
[2] *Proc. Roy. Soc.*, vol. 42, p. 331.
[3] *Proc. Physiolog. Soc.*, 1887.

great part thrown down in the dialyser, while the albumose remains in solution. The globulin is now removed by filtration, and washed with distilled water (previously boiled to sterilise it) for two days, in order to remove any albumose or sodium chloride clinging to the precipitate, the absence of the albumose being tested by the washings giving no reactions for a soluble proteid, and the absence of the salt by a negative reaction with silver nitrate. The globulin is then removed from the filter and dried over sulphuric acid. Prepared in this way, it is a whitish-yellow, amorphous powder, soluble for the most part in 15 per cent. sodium chloride, and giving the reactions previously described. In the dried state, it may be kept for a long time without losing its physiological properties. Specimens prepared for more than fifteen months are as active now as when first dried. This fact is, indeed, only in accordance with the behaviour of other dried proteids; they can be kept an indefinite time in the dried state without undergoing any chemical change.

The albumose was prepared by making a concentrated watery extract of the seeds, and filtering the clear infusion direct into an excess of absolute alcohol, thus throwing down both proteids as a white precipitate. After a few days the precipitate was removed, redissolved in water, and reprecipitated by alcohol, this process being repeated at intervals of a few months. The precipitate was allowed to stand under alcohol for about eight months or longer, at the end of which time the globulin was completely coagulated, while the albumose was still soluble in water. Dried over sulphuric acid, the residue was a yellowish-brown, amorphous powder, consisting of coagulated globulin and unaltered albumose.

*Physiological Action of the Proteids of Jequirity.*[4]—For subcutaneous injection and for instilling into the eye, a solution of the proteids was made. The globulin was dissolved in 15 per cent. sodium chloride solution, and the albumose in distilled water or normal saline solution (0·75 per cent. NaCl). Previous to using these liquids or solvents, they were well boiled to sterilise them, and then cooled. A weighed quantity of the proteid was then dissolved and used in the experiment; or a solution of the proteid was made, and the quantity present was estimated.

*Local Action on the Eye.*—A watery infusion of the seeds when instilled into the eye produces, as is well known, severe inflammation with purulent discharge; and it is this action which is beneficial in the treatment of granular lids and of pannus. Both the globulin and the albumose of jequirity possess this property. Thus in one experiment 2 milligrammes of the solid globulin (containing some coagulated proteid) were placed on the inner surface of the left eyelid of a large rabbit. In seventeen hours and three-quarters the conjunctiva was reddened and slightly swollen; there was no chemosis, but there was a clear serous discharge. In twenty-four hours, there was intense purulent ophthalmia, with subconjunctival ecchymosis; the cornea being quite clear. The purulent discharge lasted till the death of the animal, eighty-three hours after inoculation; the animal being apparently ill for about four hours before death. At the *post-mortem*, there was severe subconjunctival hæmorrhage, with œdema round the eyeball. If the dose be smaller, the animal does not die after eye inoculation, nor does it suffer from any general symptoms; but local inflammation and œdema with purulent discharge always follow in about sixteen or seventeen hours.

One milligramme of the albumose dissolved in two minims of sterilised distilled water, when placed on the eye of a rabbit, produced in less than twenty-four hours severe conjunctivitis with chemosis, and left at the end of six days a steamy cornea with leucomata and subconjunctival ecchymosis. The animal showed no symptoms of poisoning. Both globulin and albumose therefore possess this property of producing severe conjunctivitis.

*General Action on the Body.*—The symptoms produced by the subcutaneous injections of the proteids of jequirity are those which have been described by Drs. Warden and Waddell. The action of the globulin is not, however, quite identical with that of the albumose. In the first place, the globulin is more poisonous than the albumose. In rats, for example, 10 milligrammes of globulin per kilo of body-weight is a fatal dose, and in the same animals 60 miligrammes of albumose per kilo of body-weight.

If the above mentioned dose of globulin be injected into a rat, symptoms of poisoning begin to appear in about six hours; the animal then seems a little languid, and in a condition impossible to distinguish from sleepiness. It continues in this state, making no voluntary movement, irresponsive to slight external stimuli, and with half shut eyes. It lies huddled up in its cage, the breathing becomes more rapid and bloody motions are passed shortly before death, which occurs in about twenty-four hours after inoculation. If the animal is with young, it aborts. *Post mortem*, there are signs of œdema and punctiform ecchymoses at the seat of injection, and punctiform ecchymoses also beneath the peritoneum, and sometimes in the lungs. The intestines are congested, and sometimes greatly inflamed; the adenoid patches in the mucous membrane are swollen, and submucous ecchymoses are often seen. The blood sometimes remains fluid for a long time, and is sometimes coagulated. The symptoms of poisoning by the albumose and the *post-mortem* signs are similar to those described as produced by the globulin.

It may be pointed out that there are no symptoms referable to definite lesions of the organs, except the occurrence of bloody motions due to gastro-enteritis. The sleepiness in gradually increasing coma may be explained by an effect on the cerebrum; as there is not sufficient dilatation of the vessels of the abdominal organs to explain the occurrence of coma by drainage into the "splanchnic area." The occurrence of rapid breathing, which is produced chiefly by the globulin, may be explained by an affection of the respiratory centre. The only early symptom of abrus poisoning is a fall of body temperature, and this is produced both by the globulin and the albumose. In the two following charts, this effect is represented, as well as the effect on the breathing. The first chart (Fig. 1) represents the effect on the temperature of the pigeon, the temperature being taken every half hour in the rectum, and the respirations counted at the same time. The dose given was very large, but the same phenomena were noticed with smaller lethal doses.

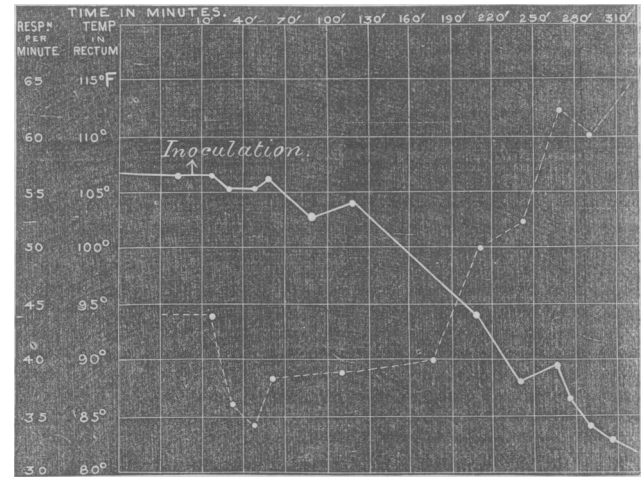


Fig. 1.—Pigeon weighing 216 grammes: 0.2 gramme abrus globulin injected over pectoral muscle (0.925 gramme per kilogramme of body weight). Death in 5 hours 45 minutes. Temperature curve, thick line; respiration curve, dotted line.

It will be seen from the chart that the temperature, which was 106.8° F. before inoculation, began to fall in less than half an hour after the poison had been injected; that this fall was gradual until two hours after the inoculation, after which time there is a rapid fall until death. The fall of temperature until death was from 106.8° to 83° F., that is, 23.8° F. or 12.6° C.

The respirations are seen from the curve to diminish more rapidly than the temperature falls for 55 minutes after inoculation; there is then a stationary period until 115 minutes, after which the number of respirations per minute rapidly rises until death. The curves, therefore, show a fall of temperature with an increase in the number of respirations.

The second chart (Fig. 2) shows a similar effect of the albumose on the temperature; but, as is seen, the respirations do not rise before death, but fall.

A pigeon weighing 335 grammes was given hypodermically a dose of 20 milligrammes albumose, equal to 60 milligrammes per kilogramme of body weight. In four hours and a half the animal

[4] The action of the globulin was investigated in co-operation with Dr. Wolfenden; for the account of the albumose I alone am responsible. The results are published in two papers in *Proc. Roy. Soc.*, May, 1889.

began to show symptoms of poisoning, and died in about six hours or rather longer. The temperature began to fall from the first, and, with a few rises, continued to fall until the animal was nearly dead, when the observations ceased. The curve of the number of respirations per minute follows very closely the temperature curve, until just before symptoms of poisoning appeared, when, as will be seen in the chart, the respiration curve does not follow the temperature curve.

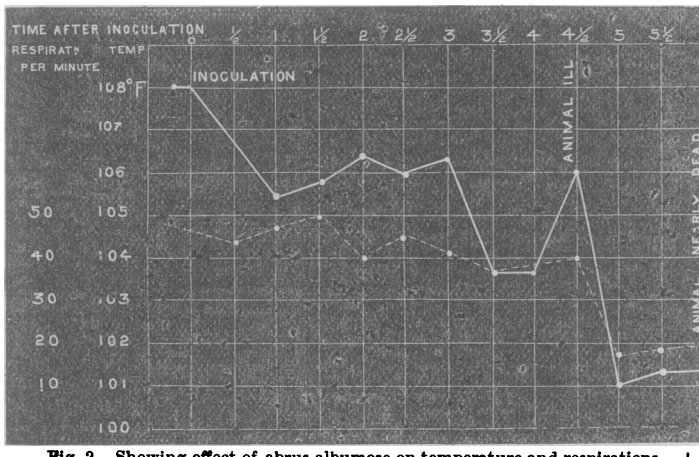


Fig. 2.—Showing effect of abrus albumose on temperature and respirations of the pigeon. Temperature taken in rectum every half-hour. Dotted line, respirations; thick line, the temperature.

This lowering effect of the jequirity proteids on body temperature was noticed in cats by Warden and Waddell. It is important, when taken in consideration with the fact that rattlesnake venom produces a similar effect (Weir-Mitchell and Reichert), and that, on the other hand, animal albumoses and peptones have been shown by Ott and Collmar[5] to produce fever in mammals.

*Effect of Heat on the Activity of Jequirity Proteids.*—Boiling the liquid destroys the activity of the infusion of jequirity seeds. This, as has been mentioned, is an argument against the bacterial nature of the poison. It was desirable to test, however, with exactness at what temperature this activity was permanently destroyed. For this purpose solutions of the globulin and albumose were momentarily heated up to 50°, 60°, 75°, 80°, 85° C. before being used for inoculation. In each separate series of experiments an unheated solution of proteid was also inoculated, in order to have a control, and a lethal dose was always used. For the details of these experiments the papers in the *Proceedings of the Royal Society*, already quoted, must be referred to. Suffice it to say here that the results obtained were—(1) that the activity of the globulin was permanently destroyed by momentarily heating its solution to between 75° and 80° C., that is, about its coagulation temperature, while the solution of albumose had to be heated up to 85° C. before the activity of the proteid was destroyed; (2) that momentary heating of the solution to above 50° C. but below 75° in the case of the globulin, and 85° in the case of the albumose, weakened the activity of the proteid without destroying it.

The conclusions therefore arrived at regarding the jequirity poison may be thus summarised:—

1. The toxic action of the jequirity (abrus precatorius) resides in two proteids—a globulin and an albumose.

2. Both these proteids produce nearly the same effects, namely, local œdema and ecchymosis at the seat of inoculation, with ecchymoses in the serous membranes, and gastro-enteritis, the blood in many cases remaining fluid. The general symptoms are a gradual sleepiness, ending in coma, with rapid onset of rigor mortis.

3. That both portions have a remarkable lowering effect on the body temperature; the globulin, at the same time, producing rapidity of breathing, while the albumose does not have this effect to the same degree.

4. That the activity of both proteids is destroyed by a temperature below the boiling point of water; the globulin between 75° and 80° C. and the albumose at 85° C., while temperatures below these points but above 50° C. diminish the poisonous activity.

*Relation of the Abrus Poison to Snake Venom.*—It is chiefly due to the researches of Weir-Mitchell that the poisonous principles of snake venom have been shown to be of an albuminoid nature. In the latest publication on the subject Weir-Mitchell and Reichert[6] affirm as the result of their analyses and experiments that the poisonous proteids present are of two kinds—a globulin and a peptone, or peptone-like body; that all kinds of venom contain these two bodies, although in varying proportions, speaking generally, the globulin being greater in proportion to the "peptone" in viperine snakes (such as the rattlesnake), and the peptone being in greater proportion in the venom of colubrine snakes, such as the cobra; that both the globulin and peptone of the venom are poisonous, producing practically the same general symptoms, but with this exception (and a noticeable one it is), that the great local ecchymosis and inflammation of snake-bite is due to the globulin present in the venom and not to the "peptone."

For reasons which I have detailed elsewhere,[7] it seems to me that Weir-Mitchell and Reichert's venom "peptone" is not a true peptone, but belongs to the albumose class of proteid bodies. The relation of abrus poison to snake venom is now apparent. Abrus seed contains two poisonous proteids—a globulin and an albumose—which both produce local œdema and ecchymosis. Rattlesnake venom also contains a globulin and a peptone-like body (probably an albumose), the former of which produces local ecchymosis and inflammation. The resemblance is further strengthened by the fact that heat diminishes the activity of both abrus poison and of snake venom; but in this respect abrus poison seems to be more sensitive than venom. Thus, even after boiling and filtering, rattlesnake venom, if given in sufficient dose, is fatal; and cobra venom is still active (although permanently destroyed by boiling for half an hour), while, with abrus proteids, a momentary heating of the globulin in a solution up to 80° C. is sufficient to destroy its activity, while with the albumose the destroying temperature is 85° C. Rattlesnake venom, like abrus poison, also lessens the body temperature. The great difference, however, between snake venom and abrus poison rests in the fact that venom produces local paralysis and general convulsions while abrus has no such effect. Abrus seems to affect the cerebral hemispheres, producing stupor, ending in coma.

It is evident, therefore, that while abrus poison bears some resemblance to snake venom it is far from being identical with it.

*Nature of Abrus Poison.*—At present it is not explicable why proteids should be poisonous; why, when injected subcutaneously or into the venous system, they should cause death. And so anomalous does the toxic power of these bodies seem that we are bound to consider whether a proteid is of itself poisonous or possesses toxic properties by virtue of some agent or body tacked on to it or formed from it. Such an agent associated with a proteid would be called a "ferment." We know that the ferments used in digestion are normally associated with proteids, although Cohnheim claimed that he had separated ptyalin from all associated proteid, and Brücke stated the same of pepsin; and even granting that these two ferments may be separated from their associated proteids the fact remains that ferments are in nature closely linked with albuminoid bodies. What characteristics of unorganised ferments, we may fairly ask, are present in abrus poison which would lead to the supposition that what might be called a "toxic" ferment is present? The unorganised ferments known alter the constitution of the bodies on which they act, the digestive ferments acting on proteids, amyloids, and fats, while other ferments, such as the fibrin ferment and the curdling ferments, cause the proteids on which they act to assume a solid form. All these ferments have certain characteristics common to all; their action is increased by a moderate heat and permanently destroyed by boiling their solutions; and their activity is not apparently diminished after they have produced their effect.

From this it will be seen that the fact which would point to abrus poison being a "toxic" ferment is the fact that its activity is permanently destroyed by a moist heat below 100° C. Farther than this we cannot at present go. Abrus globulin and albumose possess neither a proteolytic nor amylolytic action, whatever the reaction of the digestive mixture may be. The fact that the activity of the globulin is destroyed at about its coagulation temperature would seem to point to an alteration in the constitution of the proteid as the cause of the loss of poisonous activity; but this again is the temperature at which ferments are destroyed. No evident effect, chemical or physical, is noticed if the albumose

[5] *Journal of Physiology*, vol. viii, p. 218.

[6] *Researches upon the Venom of Poisonous Serpents.* Philadelphia, 1885.

[7] *Proc. Roy. Soc.*, May, 1889.

be heated up to 85° C. or even boiled, yet its toxic activity is at once and for ever destroyed. This may point to a ferment associated with the albumose; but until we know the chemical constitution of the proteid molecule we cannot assert that this degree of heat does not so alter the construction as to prevent the development of the toxic action. In this uncertain condition the matter must at present rest. It may be considered that the toxic action is not due to the proteid nor to a ferment attached to it, but to some chemical toxic body carried down with the proteid in its preparation. The effect of heat on the toxic activity of abrus would seem at once to dispose of this view. Toxic bodies, such as ptomaines and leucomaines, formed from proteids, are not so sensitive to heat as the abrus poison; and if the details of the preparation of abrus globulin and albumose be referred to[8] it will be seen that the prolonged dialysis in running water and the long extraction of the albumose by alcohol preclude the presence of any crystalline product in the residue obtained.

## REPORT OF INVESTIGATIONS IN FOURTEEN SCHOOLS IN LONDON, TO BE PRESENTED TO THE COMMITTEE APPOINTED BY THE PSYCHOLOGICAL SECTION OF THE BRITISH MEDICAL ASSOCIATION.[1]

PREPARED BY

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Honorary Secretary to the Committee.

Two applications having been made by the Committee to the School Board for London, and on each occasion the reply having been received that the Board regretted that they must decline our request to be allowed to visit their schools for the purposes of this investigation, the London members of the committee were obliged to confine their observations to other elementary schools.

The following summary of a draft report on fourteen schools in London has been prepared by Dr. Hack Tuke, Dr. G. E. Shuttleworth, Dr. Fletcher Beach, and Dr. Francis Warner.

A form of schedule was drawn up, upon which the facts noted concerning every child who appeared in any way exceptional were recorded; the report of the teacher concerning each child was included.

Ten public elementary schools; two certified industrial schools the district pauper schools, Hanwell; and the Asylum for Deaf and Dumb Children in Old Kent Road, were examined. In every case the members of committee visiting the schools were received with uniform courtesy, and they desire to acknowledge the intelligent assistance received from the managers and teachers. The committee also desire to express their thanks to Dr. Littlejohn, of Hanwell, and to Dr. Martyn, medical officer to the School for Dumb Children. Mr. Rowland Hamilton, a Vice-President of the Statistical Society, has rendered most able and generous assistance in tabulating these results.

*Mental Dulness was observed or reported to us in 231 cases.*—It is probable that many more children were mentally dull; of those noted, some attracted attention in other ways, and some were presented to us by the teachers. The method of examining children by facts observed without questions asked may indicate the condition of development and state of brain, but it is necessary to question the pupil in order to demonstrate mental aptitude or its absence.

[8] *Proc Roy. Soc., loc. cit.*

[1] Towards the expenses of this inquiry a grant was received from the Scientific Grants Committee of the British Medical Association.

The ten public elementary schools contained at the time of our visits 3,931 children; these are arranged according to standard and sex in Table A.

TABLE A.

| | Boys. | Girls. | Totals. |
|---|---|---|---|
| Infants ... ... | 759 | 764 | 1,523 |
| Standard I ... | 265 | 223 | 488 |
| ,, II ... | 213 | 236 | 449 |
| ,, III ... | 220 | 212 | 432 |
| ,, IV ... | 180 | 213 | 393 |
| ,, V ... | 152 | 141 | 293 |
| ,, VI ... | 93 | 97 | 190 |
| ,, VII ... | 46 | 70 | 116 |
| ,, ex.VII ... | 16 | 31 | 47 |
| Totals ... ... | 1,944 | 1,987 | 3,931 |

The children seen were distributed as follows in the schools thus:

TABLE B.

| | Seen in the Schools. | | | Noted on the Schedules. | | |
|---|---|---|---|---|---|---|
| | Boys. | Girls. | Totals | Boys. | Girls. | Totals |
| Fourteen London schools, namely: In 10 public elementary schools:— | | | | | | |
| Borough Road School ... ... ... | 239 | — | 239 | 60 | — | 60 |
| Stockwell Girls' School ... ... ... | — | 451 | 451 | — | 82 | 82 |
| ,, Mixed School ... ... ... | 103 | 66 | 169 | 11 | 10 | 21 |
| ,, Kindergarten ... ... ... | 42 | 42 | 84 | 5 | 1 | 6 |
| St. Andrew's National School, Wells Street, W. ... ... ... ... ... | 204 | 189 | 393 | 23 | 19 | 42 |
| St. Mary's National School, York Street, W. ... ... ... ... ... ... | 270 | 234 | 504 | 36 | 27 | 63 |
| St. Mary's National School, Whitechapel | 274 | 202 | 476 | 31 | 20 | 51 |
| Hanwell National School, W. ... ... | 326 | 278 | 604 | 44 | 20 | 64 |
| Mill Hill National School, N.W. ... | 76 | 59 | 135 | 11 | 4 | 15 |
| Jews' Infant School, Whitechapel ... | 410 | 466 | 876 | 33 | 31 | 64 |
| Total ... ... ... ... ... | 1,944 | 1,987 | 3,931 | 254 | 214 | 468 |
| In four special schools:— | | | | | | |
| District Pauper School, Hanwell ... | 637 | 440 | 1,077 | 85 | 44 | 129 |
| St. Vincent's Industrial School ... ... | 182 | — | 182 | 132 | — | 132 |
| St. Margaret's Industrial School ... | — | 103 | 103 | — | 29 | 29 |
| * School for Deaf-and-Dumb ... ... | 31 | 20 | 51 | 31 | 20 | 51 |
| Total ... ... ... ... ... | 2,794 | 2,550 | 5,344 | 502 | 307 | 809 |

* See Table L.

In special schools:—Boys, 850; girls, 563; Total, 1413.
Of which on schedules: Boys, 218; Girls, 93; Total, 341.

The following table (C) is given to indicate the principal facts observed. Several special conditions often coexisted in the same case. Further analysis and descriptions of combined conditions are given in succeeding tables.

TABLE C.

| — | — | Boys. | Girls | Totals |
|---|---|---|---|---|
| | We took notes of 809 cases in the schools ... | 502 | 307 | 809 |
| See Table E | Cases showing signs of nervousness, nerve-weakness, or defect ... ... ... | 207 | 144 | 351 |
| ,, F | Cases in which nutrition appeared to be defective ... ... ... ... | 100 | 84 | 184 |
| ,, G | Cases in which mental dulness was reported or observed by us ... ... ... | 153 | 78 | 231 |
| ,, H | Cases presenting cranial abnormalities ... | 166 | 65 | 231 |
| ,, I | Cases with disease or defect of eyes ... | 74 | 75 | 149 |

TABLE D.—*Showing the Distribution of the Various Pathological Conditions in the Different Schools, also Relations to Sex.*

| School. | Nervousness or Nerve Weakness. | | | Low Nutrition. | | | Mental Dulness. | | | Cranial Abnormalities. | | | Eye Cases. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Boys. | Girls. | Total. | Boys. | Girls. | Total. | Boys. | Girls. | Total. | Boys. | Girls. | Total. | Boys. | Girls. | Total. |
| Borough Road College Practising School ... ... ... | 30 | 0 | 30 | 11 | 0 | 11 | 17 | 0 | 17 | 10 | 0 | 10 | 5 | 0 | 5 |
| Stockwell College Practising School * ... ... ... ... | 0 | 60 | 60 | 0 | 17 | 17 | 0 | 10 | 10 | 0 | 4 | 4 | 0 | 14 | 14 |
| ,, ,, Mixed School ... ... ... ... ... | 4 | 4 | 8 | 4 | 4 | 8 | 4 | 2 | 6 | 2 | 1 | 3 | 3 | 3 | 6 |
| ,, ,, Kindergarten ... ... ... ... ... | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 4 | 1 | 1 | 2 | 0 | 0 | 0 |
| St. Andrew's, Wells Street, W. ... ... ... ... ... | 7 | 9 | 16 | 10 | 5 | 15 | 11 | 4 | 15 | 8 | 3 | 11 | 4 | 5 | 9 |
| St. Mary's, York Street, W.... ... ... ... ... ... | 14 | 11 | 25 | 8 | 8 | 16 | 9 | 6 | 15 | 14 | 4 | 18 | 7 | 12 | 19 |
| St. Mary's, Whitechapel ... ... ... ... ... ... | 12 | 7 | 19 | 7 | 6 | 13 | 8 | 1 | 9 | 10 | 7 | 17 | 3 | 6 | 9 |
| National School, Mill Hill, N.W. ... ... ... ... | 3 | 2 | 5 | 3 | 3 | 6 | 1 | 2 | 3 | 3 | 1 | 4 | 3 | 1 | 4 |
| National School, Hanwell, W. ... ... ... ... ... | 8 | 8 | 16 | 15 | 4 | 19 | 15 | 6 | 21 | 17 | 8 | 25 | 14 | 3 | 17 |
| Jews' Infant School, Whitechapel ... ... ... ... | 11 | 10 | 21 | 14 | 13 | 27 | 11 | 10 | 21 | 17 | 8 | 25 | 8 | 8 | 16 |
| | 89 | 111 | 200 | 72 | 60 | 132 | 79 | 42 | 121 | 82 | 37 | 119 | 47 | 52 | 99 |
| District Pauper Schools, Hanwell, W. ... ... ... ... | 37 | 13 | 50 | 6 | 7 | 13 | 38 | 15 | 53 | 32 | 14 | 46 | 15 | 12 | 27 |
| School for Deaf and Dumb, Old Kent Road..... ... ... | 15 | 6 | 21 | 5 | 4 | 9 | 4 | 2 | 6 | 14 | 4 | 18 | 2 | 3 | 5 |
| St. Vincent's Certified Industrial School, Dartford ... ... | 66 | 0 | 66 | 17 | 0 | 17 | 32 | 0 | 32 | 38 | 0 | 38 | 10 | 0 | 10 |
| St. Margaret's Certified Industrial School, Mill Hill, N.W. | 0 | 14 | 14 | 0 | 13 | 13 | 0 | 19 | 19 | 0 | 10 | 10 | 0 | 8 | 8 |
| | 118 | 33 | 151 | 28 | 24 | 52 | 74 | 36 | 110 | 84 | 28 | 112 | 27 | 23 | 50 |
| As above ... ... ... ... ... | 89 | 111 | 200 | 72 | 60 | 132 | 79 | 42 | 121 | 82 | 37 | 119 | 47 | 52 | 99 |
| Total ... ... ... ... ... | 207 | 144 | 351 | 100 | 84 | 184 | 153 | 78 | 231 | 166 | 65 | 231 | 74 | 75 | 149 |
| | See Table E. | | | See Table F. | | | See Table G. | | | See Table H. | | | See Table I. | | |

* This school was visited immediately after the annual inspection by Her Majesty's Inspector. The Standards III to VII, containing 302 girls, were seen by us five months later, when 29 showed nerve-signs.

*Cases in which we observed Signs of Nervousness, Nerve-Weakness, or Nerve-Defect are Analysed in Table E.*—It is probable that in some of these cases the signs of nervousness or nerve-weakness were only temporary in character.

TABLE E.

| Distribution of Nerve Conditions. | Boys. | Girls. | Totals | Low Nutrition. Boys. | Girls. | Totals |
|---|---|---|---|---|---|---|
| Infants ... ... ... ... ... ... | 14 | 18 | 32 | 6 | 8 | 14 |
| Standard I ... ... ... ... | 20 | 7 | 27 | 10 | 4 | 14 |
| ,, II ... ... ... ... | 11 | 9 | 20 | 6 | 2 | 8 |
| ,, III ... ... ... ... | 6 | 14 | 20 | 2 | 5 | 7 |
| ,, IV ... ... ... ... | 6 | 17 | 23 | 2 | 4 | 6 |
| ,, V ... ... ... ... | 13 | 9 | 22 | 2 | 2 | 4 |
| ,, VI ... ... ... ... | 11 | 14 | 25 | 4 | 4 | 8 |
| ,, VII ... ... ... ... | 6 | 18 | 24 | 0 | 1 | 1 |
| ,, ex. VII ... ... ... ... | 2 | 5 | 7 | — | — | — |
| Ten public elementary schools ... ... | 89 | 111 | 200 | 32 | 30 | 62 |
| Pauper school... ... ... ... ... | 37 | 13 | 50 | | | |
| Two industrial schools ... ... ... | 66 | 14 | 80 | | | |
| School for deaf and dumb... ... ... | 15 | 6 | 21 | | | |
| | 118 | 33 | 151 | | | |
| Ten public elementary schools as above | 89 | 111 | 200 | | | |
| Fourteen London schools ... ... ... | 207 | 144 | 351 | | | |

| — | Boys. | Girls. | Totals. |
|---|---|---|---|
| As coincident conditions, we found in the 200 cases in 10 public elementary schools: | | | |
| Defective nutrition ... ... ... ... | 32 | 30 | 62 |
| Mental dulness ... ... ... ... ... | 23 | 20 | 43 |
| Cranial abnormalities... ... ... ... | 28 | 16 | 44 |
| In the 50 cases observed in the pauper school: | | | |
| Defective nutrition ... ... ... ... | 2 | 5 | 7 |
| Mental dulness ... ... ... ... ... | 15 | 5 | 20 |
| Cranial abnormalities ... ... ... ... | 12 | 3 | 15 |
| In the 80 cases observed in the two industrial schools: | | | |
| Defective nutrition ... ... ... ... | 10 | 4 | 14 |
| Mental dulness ... ... ... ... ... | 18 | 4 | 22 |
| Cranial abnormalities... ... ... ... | 13 | 4 | 17 |
| In the 21 cases observed in the school for deaf and dumb children: | | | |
| Defective nutrition ... ... ... ... | 2 | 3 | 5 |
| Mental dulness ... ... ... ... ... | 4 | 1 | 5 |
| Cranial abnormalities ... ... ... ... | 6 | 2 | 8 |

*Signs of Defective Nutrition were seen in 132 cases.*—We do not suppose that we noted defective nutrition in all the cases in which it may have been present. The distribution of these cases, according to standards and sex, is shown in Table F.

TABLE F.

| — | Boys. | Girls. | Totals. |
|---|---|---|---|
| Infants ... ... ... ... ... ... | 21 | 19 | 40 |
| Standard I ... ... ... ... ... | 16 | 7 | 23 |
| ,, II ... ... ... ... ... ... | 12 | 11 | 23 |
| ,, III ... ... ... ... ... ... | 5 | 4 | 9 |
| ,, IV ... ... ... ... ... ... | 6 | 9 | 15 |
| ,, V ... ... ... ... ... ... | 8 | 3 | 11 |
| ,, VI ... ... ... ... ... ... | 2 | 5 | 7 |
| ,, VII ... ... ... ... ... ... | 2 | 2 | 4 |
| Ex. VII ... ... ... ... ... ... | — | — | — |
| Ten public elementary schools ... ... ... | 72 | 60 | 132 |
| Pauper school ... ... ... ... ... ... | 6 | 7 | 13 |
| Two industrial schools ... ... ... ... | 17 | 13 | 30 |
| School for deaf and dumb ... ... ... ... | 5 | 4 | 9 |
| | 28 | 24 | 52 |
| For 10 public elementary schools (as above) ... | 72 | 60 | 132 |
| For 14 London schools ... ... ... ... | 100 | 84 | 184 |
| As coincident conditions, we found in the 132 cases in 10 public elementary schools: | | | |
| Signs of nervousness, nerve-weakness or defect ... ... ... ... ... ... | 32 | 30 | 62 |
| Mental dulness ... ... ... ... ... | 30 | 17 | 47 |
| Cranial abnormalities... ... ... ... | 28 | 15 | 43 |
| In the 13 cases observed in the pauper school: | | | |
| Signs of nervousness, nerve-weakness or defect ... ... ... ... ... ... | 2 | 5 | 7 |
| Mental dulness ... ... ... ... ... | 2 | 2 | 4 |
| Cranial abnormalities ... ... ... ... | 3 | 2 | 5 |
| In the 30 cases observed in the two industrial schools: | | | |
| Signs of nervousness, nerve-weakness or defect ... ... ... ... ... ... | 10 | 4 | 14 |
| Mental dulness ... ... ... ... ... | 7 | 9 | 16 |
| Cranial abnormalities... ... ... ... | 8 | 5 | 13 |
| In the 9 cases observed in the school for deaf and dumb children: | | | |
| Signs of nervousness, nerve-weakness or defect ... ... ... ... ... ... | 2 | 3 | 5 |
| Mental dulness ... ... ... ... ... | 1 | 1 | 2 |
| Cranial abnormalities ... ... ... ... | 4 | 2 | 6 |

TABLE G.—*Cases of Mental Dulness.*

| — | Boys. | Girls. | Totals. |
|---|---|---|---|
| Infants | 26 | 17 | 43 |
| Standard I | 12 | 5 | 17 |
| ,, II | 6 | 8 | 14 |
| ,, III | 11 | 2 | 13 |
| ,, IV | 6 | 4 | 10 |
| ,, V | 14 | 1 | 15 |
| ,, VI | 1 | 3 | 4 |
| ,, VII | 3 | 2 | 5 |
| Ex. VII | — | — | — |
| In the 10 public elementary schools | 79 | 42 | 121 |
| Pauper school | 38 | 15 | 53 |
| Two industrial schools | 32 | 19 | 51 |
| School for deaf and dumb | 4 | 2 | 6 |
| | 74 | 36 | 110 |
| For the 10 public elementary schools (as above) | 79 | 42 | 121 |
| For the 14 London schools | 153 | 78 | 231 |
| As coincident conditions, we found in the 121 cases in 10 public elementary schools: | | | |
| Signs of nervousness, nerve-weakness, or defect | 23 | 17 | 40 |
| Defective nutrition | 29 | 17 | 46 |
| Cranial abnormalities | 21 | 6 | 27 |
| In the 53 cases observed in the pauper school: | | | |
| Signs of nervousness, nerve-weakness, or defect | 15 | 5 | 20 |
| Defective nutrition | 2 | 2 | 4 |
| Cranial abnormalities | 17 | 5 | 22 |
| In the 51 cases observed in the 2 industrial schools: | | | |
| Signs of nervousness, nerve-weakness, or defect | 18 | 4 | 22 |
| Defective nutrition | 7 | 9 | 16 |
| Cranial abnormalities | 10 | 7 | 17 |
| In the 6 cases observed in the school for deaf and dumb children: | | | |
| Signs of nervousness, nerve-weakness, or defect | 4 | 1 | 5 |
| Defective nutrition | 1 | 1 | 2 |
| Cranial abnormalities | 4 | 1 | 5 |

TABLE H.—*Cranial Abnormalities.*

| — | Ten Public Elementary Schools. | | | Pauper School. | | | Two Industrial Schools. | | | Deaf and Dumb School. | | | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B. | G. | T. | B. | G. | T. | B. | G. | T. | B. | G. | T. | |
| Probably rickets | 24 | 5 | 29 | 5 | 3 | 8 | — | — | — | — | — | — | 37 |
| Head large, cause not known | 17 | 7 | 24 | 8 | 1 | 9 | — | 1 | 1 | 1 | — | 1 | 35 |
| Head small, ,, ,, | 5 | 3 | 8 | 1 | — | 1 | 1 | 3 | 4 | 2 | 1 | 3 | 16 |
| Dolichocephalic or scaphocephalic | 7 | 2 | 9 | 3 | — | 3 | 1 | 3 | 4 | 1 | — | 1 | 17 |
| Forehead narrow or shallow, not included in other groups | 14 | 9 | 23 | 10 | 6 | 16 | 12 | 2 | 14 | 3 | 1 | 4 | 57 |
| Bosses on frontal bone or at fontanelle; not included in other groups | 12 | 9 | 21 | 3 | 3 | 6 | 18 | 1 | 19 | 5 | 2 | 7 | 53 |
| Other defects of skull not included in other groups | 3 | 2 | 5 | 2 | 1 | 3 | 6 | — | 6 | 2 | — | 2 | 16 |
| | 82 | 37 | 119 | 32 | 14 | 46 | 38 | 10 | 48 | 14 | 4 | 18 | 231 |

| — | Boys. | Girls. | Totals. |
|---|---|---|---|
| As coincident conditions we found the 82 boys, 37 girls—total, 119 cases, in 10 public elementary schools: | | | |
| Signs of nervousness, nerve-weakness, or defect | 28 | 16 | 44 |
| Defective nutrition | 28 | 15 | 43 |
| Mental dulness | 21 | 6 | 27 |
| In the 46 cases observed in the pauper school: | | | |
| Signs of nervousness, nerve-weakness, or defect | 12 | 3 | 15 |
| Defective nutrition | 3 | 2 | 5 |
| Mental dulness | 17 | 5 | 22 |
| In the 2 industrial schools: | | | |
| Signs of nervousness, nerve-weakness, or defect | 13 | 4 | 17 |
| Defective nutrition | 8 | 5 | 13 |
| Mental dulness | 10 | 7 | 17 |
| In the 17 cases observed in the school for deaf and dumb children: | | | |
| Signs of nervousness, nerve-weakness, or defect | 6 | 2 | 8 |
| Defective nutrition | 4 | 2 | 6 |
| Mental dulness | 4 | 1 | 5 |

TABLE K.

| Total of Cases presenting each Nerve-Sign Respectively. | | | | Nervous Hand. | | | Weak Hand. | | | Lordosis. | | | Frontals Over-acting. | | | Orbicular Muscle of Eyelids Toneless. | | | Finger Twitches. | | | Number of Nerve-Signs not in Combination. | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nervous Hand. | B. | G. | T. | B. | G. | T. | B. | G. | T. | B. | G. | T. | B. | G. | T. | B. | G. | T. | B. | G. | T. | Nervous Hand. | B. | G. | T. |
| In 10 public elementary schools... | 44 | 69 | 113 | | | | | | | 10 | 28 | 38 | 9 | 1 | 10 | 5 | 4 | 9 | 15 | 16 | 31 | In 10 public elementary schools... | 21 | 28 | 49 |
| ,, 4 special schools... ... ... | 25 | 5 | 30 | | × | | | — | | *6* | *2* | *8* | *7* | *0* | *7* | | — | | *6* | *2* | *8* | ,, *4 special schools* ... ... ... | *11* | *3* | *14* |
| | 69 | 74 | 143 | | | | | | | | | | | | | | | | | | | | | | |
| Weak Hand. | | | | | | | | | | | | | | | | | | | | | | Weak Hand. | | | |
| ,, 10 public elementary schools... | 10 | 22 | 32 | | — | | | | | 1 | 6 | 7 | 3 | 0 | 3 | 1 | 3 | 4 | 3 | 5 | 8 | ,, 10 public elementary schools ... | 5 | 9 | 14 |
| ,, 4 special schools... ... ... | 16 | 6 | 22 | | — | | | × | | *3* | *3* | *6* | *6* | *1* | *7* | *2* | *1* | *3* | *3* | *3* | *6* | ,, *4 special schools* ... ... ... | *5* | *2* | *7* |
| | 26 | 28 | 54 | | | | | | | | | | | | | | | | | | | | | | |
| Lordosis. | | | | | | | | | | | | | | | | | | | | | | Lordosis. | | | |
| ,, 10 public elementary schools... | 15 | 41 | 56 | 10 | 28 | 38 | 1 | 6 | 7 | | × | | 3 | 1 | 4 | 0 | 2 | 2 | 1 | 10 | 11 | ,, 10 public elementary schools ... | 4 | 6 | 10 |
| ,, 4 special schools... ... ... | 18 | 5 | 23 | *6* | *2* | *8* | *3* | *3* | *6* | | | | *3* | *0* | *3* | *1* | *0* | *1* | *6* | *1* | *7* | ,, *4 special schools* ... ... ... | *6* | *2* | *8* |
| | 33 | 46 | 79 | | | | | | | | | | | | | | | | | | | | | | |
| Frontals Overacting. | | | | | | | | | | | | | | | | | | | | | | Frontals Overacting. | | | |
| ,, 10 public elementary schools... | 41 | 2 | 43 | 9 | 1 | 10 | 3 | 0 | 3 | 3 | 1 | 4 | | × | | 2 | 0 | 2 | 3 | 0 | 3 | ,, 10 public elementary schools ... | 25 | 0 | 25 |
| ,, 4 special schools... ... ... | 68 | 13 | 81 | *7* | *5* | *12* | *6* | *1* | *7* | *3* | *0* | *3* | | | | | — | | *8* | *2* | *10* | ,, *4 special schools* ... ... ... | *48* | *10* | *58* |
| | 109 | 15 | 124 | | | | | | | | | | | | | | | | | | | | | | |
| Orbicular Muscle of Eyelids Toneless. | | | | | | | | | | | | | | | | | | | | | | Orbicular Muscle of Eyelids Toneless. | | | |
| ,, 10 public elementary schools... | 14 | 11 | 25 | 5 | 4 | 9 | 1 | 3 | 4 | 0 | 2 | 2 | 2 | 0 | 2 | | × | | 3 | 3 | 6 | ,, 10 public elementary schools ... | 9 | 3 | 12 |
| ,, 4 special schools... ... ... | 4 | 1 | 5 | | — | | *2* | *1* | *3* | *1* | *0* | *1* | | — | | | | | | — | | ,, *4 special schools* ... ... ... | *1* | *0* | *1* |
| | 18 | 12 | 30 | | | | | | | | | | | | | | | | | | | | | | |
| Finger Twitches. | | | | | | | | | | | | | | | | | | | | | | Finger Twitches. | | | |
| ,, 10 public elementary schools... | 20 | 27 | 47 | 15 | 16 | 31 | 3 | 5 | 8 | 1 | 10 | 11 | 3 | 0 | 3 | 3 | 3 | 6 | | × | | ,, 10 public elementary schools ... | 3 | 3 | 6 |
| ,, 4 special schools... ... ... | 25 | 10 | 35 | *6* | *2* | *8* | *3* | *3* | *6* | *6* | *1* | *7* | *8* | *2* | *10* | | — | | | | | ,, *4 special schools* ... ... ... | *8* | *5* | *13* |
| | 45 | 37 | 82 | | | | | | | | | | | | | | | | | | | | | | |
| Total 10 public elementary schools ... | 39 | 49 | 88 | 8 | 14 | 22 | 15 | 47 | 62 | 20 | 2 | 22 | 11 | 12 | 23 | 25 | 34 | 59 | | | | | 67 | 49 | 116 |
| ,, *4 special schools* ... ... ... | *19* | *4* | *23* | *14* | *8* | *22* | *19* | *6* | *25* | *24* | *3* | *27* | *3* | *1* | *4* | *23* | *8* | *31* | | | | | *79* | *22* | *101* |
| Final total ... ... ... ... ... | 58 | 53 | 111 | 22 | 22 | 44 | 34 | 53 | 87 | 44 | 5 | 49 | 14 | 13 | 27 | 48 | 42 | 90 | | | | | *146* | *71* | *217* |

*Note.*—The additions at the foot of the columns include the cases of combinations with one or more of the other defects noted. The numbers in the right-hand margin indicate defects *not* in combination and might be placed in the diagonal square marked ×.

*Diseases and Defective Conditions of Eyes.*—When a child was seen wearing spectacles, with a squint or other obvious defect, the fact was noted, but many cases must have had errors of refraction not known to us.

TABLE I.

| — | Ten Public Elementary Schools. | | | Pauper School. | | | Two Industrial Schools. | | | Deaf and Dumb School. | | | Totals. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | B. | G. | T. | B. | G. | T. | B. | G. | T. | B. | G. | T. | |
| Squint ... ... ... ... ... | 32 | 26 | 58 | 9 | 3 | 12 | 4 | 4 | 8 | 2 | 1 | 3 | 81 |
| Hypermetropia ... ... ... | 3 | 15 | 18 | 1 | 3 | 4 | — | — | — | — | — | — | 22 |
| Myopia ... ... ... ... ... | 3 | 5 | 8 | 2 | — | 2 | — | — | — | — | — | — | 10 |
| Disease of Cornea ... ... ... | 3 | 2 | 5 | 2 | 3 | 5 | 4 | 4 | 8 | 1 | 1 | 2 | 20 |
| Disease of lids ... ... ... | 1 | 2 | 3 | — | — | — | — | — | — | — | — | — | 3 |
| Cataract ... ... ... ... | — | 1 | 1 | — | — | — | — | — | — | — | — | — | 1 |
| Eye lost ... ... ... ... | — | 1 | 1 | — | 1 | 1 | 2 | — | 2 | — | — | — | 4 |
| Nystagmus ... ... ... ... | 2 | 3 | 5 | 1 | 2 | 3 | — | — | — | — | — | — | 8 |
| | 14 | 55 | 99 | 15 | 12 | 27 | 10 | 8 | 18 | 3 | 2 | 5 | 149 |

Analysis of 361 cases (Table K) which showed signs of nervousness, nerve weakness, or defect, namely:

| | Boys. | Girls. | Total. |
|---|---|---|---|
| In 10 public elementary schools ... | 89 | 111 | 200 |
| „ 4 special schools ... ... ... | 123 | 38 | 161 |
| | 212 | 149 | 361 |

The association of these signs is exhibited in Table K, *q. v.*

*Analysis of 51 Deaf and Dumb Children.*—In this school each child was examined separately, and the condition of the palate was noted. Particulars as to head measurements and conditions of general physical heath were most kindly filled in by Dr. Martyn, medical officer to the institution. The secretary of the institution very kindly filled in some particulars of the history of each pupil from the records kept. The ages of these children varied from $7\frac{1}{2}$ to 11 years; average age 8 years. The following table indicates the cause assigned for the deafness:—

TABLE L.

| Deaf and Dumb Children. | Boys. | Girls. | Totals. |
|---|---|---|---|
| Congenitally deaf ... ... ... ... ... | 21 | 11 | 32 |
| Sequent to measles ... ... ... ... | 2 | 1 | 3 |
| „ „ whooping cough ... ... ... | 1 | 1 | 2 |
| „ „ scarlet fever... ... ... ... | — | 1 | 1 |
| „ „ sunstroke ... ... ... ... | 1 | — | 1 |
| Fits or brain disease ... ... ... ... ... | 3 | 2 | 5 |
| Effects of a fall ... ... ... ... ... | 2 | — | 2 |
| First dentition ... ... ... ... ... | — | 3 | 3 |
| Cause not stated ... ... ... ... ... | 1 | 1 | 2 |
| | 31 | 20 | 51 |

In 3 cases the children were the offspring of first cousins. In 5 cases deafness was acquired between the ages of 3 and 6 years; in two instances without cause assigned. The palate was examined in all these cases: in 2 cases it was "vaulted," in 2 "narrow," in 3 "arched." Of these 7 cases 5 occurred among the congenitally deaf pupils, and 3 coincided with other defects of the cranium. In 7 boys and 7 girls the teeth were found ground. The various conditions found in these children are given in preceding tables.

## REPORT ON THE MEDICO-LEGAL DETECTION OF HUMAN BLOOD.

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(From the Physiological Laboratory of St. Thomas's Hospital.)

UP to the present time, the only method which has been proposed for the purpose of distinguishing human blood from that of the lower animals is one which depends on the detection and subsequent measurement of the red blood corpuscles.

In all the textbooks will be found measurements, originally made by Gulliver, of the diameter of the red corpuscles of man and of various animals in fresh blood, since the publication of which, Richardson, of Philadelphia, U.S.A., Seiler, and others, have claimed that they are able by this means, and with the aid of high powers of the microscope, to distinguish human blood from that of the domestic animals. This, however, has reference only to fresh blood and not to dried, or partially dried, stains; while, moreover, most English and foreign skilled microscopists are agreed that it would be unsafe, by this method, to testify before a jury at a criminal trial that even a sample of fresh blood was undoubtedly human, since there are several animals (more particularly the guinea-pig, dog, hare, and rabbit) whose blood corpuscles are so precisely similar to those of man in size, that even with the highest powers of the microscope they could not with any certainty be distinguished. In addition, the factor of disease might have to be taken into consideration, since we know that in such case the size of the corpuscles may vary in the same animal within wide limits. Much more, then, would the results be open to criticism in the case of corpuscles obtained from a dried stain, since it would be impossible to say that their size had not been altered by the solvent employed, particularly as a series of experiments on the specific gravity of the blood, conducted by Dr. Sherrington and myself, has shown us that not only does the density of the blood vary in man between considerable limits, but that it has a different range, apparently, for every animal; and, consequently, it is impossible to state what should be the specific gravity necessary for a solvent which should absolutely prevent any alteration in the size of the corpuscles obtained.

What has just been stated applies particularly to mammalian blood; but it should not be forgotten that, in certain cases, valuable evidence may possibly be obtained if we have to deal with the blood of birds, fishes, reptiles, or amphibians, in which the corpuscles are oval and nucleated, since undoubtedly, with the aid of suitable solvents, they may be obtained without sufficient alteration to conceal their characteristic shape. If such evidence were forthcoming, we could at any rate be certain that we had not to deal with mammalian—inclusive, of course, of human—blood, a point which has before now been of importance in a criminal trial, where a prisoner may have accounted for certain spots of blood by the statement that he had been handling fish or game while, on the other hand, supposing always that corpuscles can be obtained, we might equally be able to say that a given stain did not consist of the blood, for instance, of a bird; but further than this we should not be justified in going.

In 1887 I published in *St. Thomas's Hospital Reports*[1] the results of an investigation into the pathology of the blood in pernicious anæmia, most of which were embodied in a paper read before the Medical and Physical Society of St. Thomas's Hospital in November, 1886. During the two years previously Dr. Bristowe had had a number of cases of this somewhat rare disease under his care in the wards of St. Thomas's Hospital, and through his kindness I had the opportunity of examining the blood on a considerable number of occasions.

I was able in great measure to confirm the conclusions previously arrived at by Eichorst, Byrom Bramwell, and others; but, in addition, I found what had not been previously noticed, that when a drop of the blood was removed from the finger and allowed to fall on a glass slide, and then when the edge of the drop had dried somewhat a cover-glass was gently placed upon it, crystals of hæmoglobin gradually formed in the film of blood in from ten to forty-eight hours, without any further preparation. The only exception to this was in the case of patients who had been treated with arsenic for some days, after which crystals could not be obtained, although if then the arsenic were discontinued for an equal length of time, they again put in an appearance. As I stated at the time, it thus appears that arsenic has a very immediate effect for good on the blood, even though for a time it may not show any very considerable change in the number of corpuscles or in the amount of hæmoglobin present.

These observations were of the greatest interest to me, because up to this time I had not been able to crystallise human blood, although crystals were obtained from the blood of some of the lower animals, whose hæmoglobin has almost precisely the same composition as in man, with the greatest ease, notably from the guinea-pig and rat. Human hæmoglobin, however, is very soluble, and, consequently, is much more difficult to obtain in the crystalline form. Rollett states that he obtained it, but although

[1] *St. Thomas's Hospital Reports*, New Series, vol. xvi, p. 155.

the crystals are figured in all the textbooks, no English physiologist to whom I have applied has been able to furnish me, from personal experience with any method of obtaining them directly from the blood, while Dr. Allchin informed me that when working at the subject of blood with Dr. Michael Foster at University College, they were quite unable to obtain any. Stirling and Brito, however, obtained them from the stomach of leeches which had fed on human blood, after a lapse of several weeks, a method which I have also followed with success.

It seemed to me, however, that it might be possible to procure crystals from human blood, in a more direct manner, by imitating as much as possible the conditions which obtain in pernicious anæmia. I was particularly struck, when examining the specific gravity of the blood in some of the later cases, by means of a modification of the method originally introduced by Professor Roy, of Cambridge, to find to what a low degree it had fallen, the specific gravity usually ranging between 1028 and 1038, while in health it should be about twenty degrees higher than the maximum of these observations.

In the disease under consideration, the low specific gravity is obviously due to the extremely small number of red corpuscles present; the plasma, therefore, being in proportionately much greater quantity than in health. Acting on the supposition that this, together with the lessened consistence of the red corpuscles, as evidenced by their abnormal shapes, might account for the formation of crystals of hæmoglobin, when the blood was removed from the body and treated in the manner described, I tried the effect of diluting normal human blood with serum, that obtained from sheep's blood being used, since it is well known that the serum of one animal tends to destroy the corpuscles of another animal into whose circulation it may be introduced, or whose blood is brought into contact with it after removal from the body.

At first my success was not great, although in a few instances crystals were formed; but on one occasion, having used some serum which had been set aside in the laboratory for some days in rather warm weather, and which had consequently become decomposed, I found that crystals appeared in every instance in which it was used.

This being the case, twenty-five members of the pathology class at St. Thomas's were selected, who seemed particularly healthy, and whose blood consequently might be supposed to be perfectly normal. Each of these gentlemen kindly allowed a few drops of blood to be abstracted from a finger, and from the blood of every one, from three to six preparations were made, which, after an interval differing slightly in each case, and apparently depending somewhat on the amount of serum added, all showed crystals of hæmoglobin.

A method, almost identical with this, was published by Mr. Bond, of Leicester, who, however, used putrid human serum, the idea in his case being an attempt to imitate the processes of septicæmia, in which, as well as in pernicious anæmia, he found the crystals of hæmoglobin formed spontaneously in the blood when allowed to dry after removal from the body, as I had formerly described, the reason for their appearance, in his opinion, being the presence in the blood of certain ferments, the result of the life-action of various micro-organisms. He further noted that the crystals, as shown by the microspectroscope, presented the bands of reduced hæmoglobin, but he does not appear to have attached any importance to the observation, neither did he give any comparative observations as to the application of the same method to the blood of the lower animals.

The crystals obtained by the method just described, are usually rectangular plates of a pink or pale claret colour when formed in a fairly thick layer of blood, or a greenish tint when the film is very thin, this agreeing with the statement of Foster, that "in dilute solutions, or in a thin layer, the reduced hæmoglobin lets through so much of the green rays that they preponderate over the red, and the resulting impression is one of green;" and there can be no doubt, both from the microscopic and spectroscopic appearances, that they really do consist of reduced, and not of oxy-hæmoglobin. This, although its significance seems to have been overlooked by Bond and others, is a point of considerable interest, since it is usually stated that although crystals of oxy-hæmoglobin may have their superfluous oxygen removed by exposure to a vacuum, they never crystallise as reduced hæmoglobin.[2] Consequently the fact that in attempting to obtain crystals of hæmoglobin from human blood reduction has not been allowed to take place, may account for the absence of success in previous endeavours.

In the paper of Stirling and Brito, quoted above, the crystals were stated to be of a pink colour, and the diagrams given in illustration show that they must have consisted of reduced hæmoglobin, although no mention is made of this fact, and in repeating the experiment this supposition has been verified.

This, then, evidently forms a diagnostic point of great importance, since there is a universal consensus of opinion, as has already been shown, that the blood of the lower animals invariably crystallises as oxy-hæmoglobin only. In order, however, to test the question satisfactorily, a number of experiments were made on the blood of various animals, by treating them with decomposing serum, and for some time the method appeared quite ineffectual, as in the case of the bullock, sheep, pig, dog, and cat no crystals could be obtained, although repeated trials were made, not only with sheep's serum, but with that of other animals; thus, for example, bullock's blood was treated with sheep's serum, sheep's blood with bullock's serum, pig's blood with both, and so on, to see whether the result was the same in all cases. In later experiments, however, it was found that crystals could be obtained by this method from the blood of the monkey, rabbit, and squirrel, but except in the case of the monkey, the crystals were found to consist, not of reduced, but of oxy-hæmoglobin, and this notwithstanding that the addition of decomposing serum invariably brought about reduction of the hæmoglobin, as it became extruded from the corpuscles and diffused through the plasma as they broke down. As stated by Bond, in his paper, this takes place to the greatest extent in a circular area just inside the edge of the coverglass, but not extending quite to the edge, where there is a layer which is kept in the oxidised condition, probably by absorption of oxygen from the outside air. It is in this intermediate zone of fully reduced hæmoglobin that crystals are to be found in greatest quantity, both in the case of human blood and of those animals in which the method succeeds, but in these latter the crystals which, as stated above are of oxy-hæmoglobin, stand out in a most marked manner from the ground-work of reduced hæmoglobin; the contrast between the uniform pale-claret coloured basis and the scarlet or more often yellow colour (from the thinness of the layer) of the crystals being most remarkable.

In the specimens of squirrel's blood prepared in this manner, it was found that in every case the resulting crystals presented the form of fine needles or rhombic prisms, the needles sometimes being collected into bundles, while in no case were the usual hexagons, so easily obtained by other methods, seen.

As far, then, as is known at present, the blood of the monkey is the only exception to the rule that when crystals are obtained from the blood of the lower animals, it invariably consists of oxy-hæmoglobin, while those which can be obtained from human blood by the use of putrid serum as invariably consist of reduced hæmoglobin. At first sight it might appear that the fact of monkey's blood acting like human, when treated with decomposing serum was a serious objection to the foundation of any method of diagnosis between the blood of man and that of other animals; but on consideration, it will, I think, be found that the obstacle is not altogether an insurmountable one; the shape of the crystals being quite different in the two cases—those of man, as I have before stated, being almost invariably rectangular plates, while the crystals obtained from monkey's blood are for the most part diamond-shaped plates, of which two adjoining sides are longer than the other two.

The blood of many animals, however, particularly of those which come under the term "domestic," altogether refuses to crystallise by the method that has been advocated for human blood, and consequently unless we can control such negative experiments with some of a more positive kind, it would obviously be unfair to base any definite opinion upon the results obtained, for although, if we find that crystals are formed, and that they consist of reduced hæmoglobin, we may say, after excluding the possibility of the blood being that of a monkey, that it undoubtedly is human; still, on the other hand, if crystals are not obtained, it would, in the absence of evidence to the contrary, be unsafe to assert positively that it was not human.

Fortunately, however, we possess also a method for carrying out such control experiments. After careful trial of the various means suggested by different observers for obtaining hæmoglobin crystals from the lower animals, I have come to the conclusion

[2] Burdon-Sanderson, *Handbook*, p. 180; Landois and Stirling, *Physiology*, second edition, p. 27; Foster, *Physiology*, fourth edition, p. 336.

that the most reliable one is that given by Gamgee,[3] which is briefly as follows: to defibrinated blood add about one-sixteenth of its volume of ether, and shake the mixture for some minutes until it becomes perfectly transparent or laky. It is then to be set aside in a cool place for a period varying from a few hours to two or three days, when crystals form in abundance. There are, however, one or two points of importance in connection with the method which have not apparently been previously noticed, and which I communicated to the Medical and Physical Society of St. Thomas's Hospital in 1887; one is that care should be taken that the blood, after it has been made laky, should be kept under an atmosphere of ether for some time, which may be accomplished by performing the agitation of the blood with ether in a stoppered bottle, and gradually allowing the air to escape as the ether is volatilised. By this means the contained air is gradually replaced by ether vapour, while at the same time the small portion of blood which is forced out around the stopper of the bottle, on drying, fixes it in its place, and so prevents ingress of air again. It appears that it is better to leave the bottle in a room at the ordinary temperature than to put it in a cool place as advised by Gamgee.

It is curious to note the discrepancies among authors who have written about the blood as to the comparative readiness with which the blood of various animals crystallises. Thus, for instance, Foster[4] states that the blood of the rat, guinea-pig, squirrel, hedgehog, horse, cat, dog, goose, and some other animals crystallises readily, while that of the ox, sheep, rabbit, pig, and man does so with difficulty. On the other hand, Yeo[5] states that the blood of the cat, dog, horse, man, ape, and rabbit crystallises readily, although he allows, with most other authorities, that the blood of the sheep, cow, and pig does so with difficulty. Both Landois and Stirling[6] and Yeo agree that coloured crystals are not obtained from the blood of the frog, a statement, however, which I have been able to disprove.

These differences of opinion are doubtless to be accounted for by the different methods employed in various instances, but, as will be noticed, there is one point of agreement in common, namely, that the blood of some of the domestic animals, such as the bullock, sheep, and pig, which in medico-legal work we are most likely to be required to distinguish from human blood, is just that which is with most difficulty crystallisable.

By employing Gamgee's method, however, in the way I propose, this apparent difficulty is altogether overcome; for I have found that, as the results of my experiments, the blood of all these animals is with certainty crystallisable, if it be allowed to remain for a sufficient time in contact with the ether. The right period is readily hit upon by removing a drop of the blood to a slide, after varying lengths of time (in the case of the animals mentioned, two days at least); and then, when the edges of the drop are slightly dry, gently lowering a thin cover-glass on the surface of the drop. The cover soon becomes fixed by the drying of the blood at the edge, and then, if the preparation be examined under the microscope, the commencing formation of radiating crystals of oxy-hæmoglobin will often be seen in an hour or so, while they gradually enlarge in size to such an extent as sometimes to occupy the whole of the space beneath the cover-glass. If, when they first become visible, the slide be "ringed" with Canada balsam or asphalte varnish, they retain their shape, often for a very considerable length of time. The crystals obtained by this method are all very similar in shape, but they all agree in differing in this respect from the right-angled plates which are obtained from human blood.

It is advisable, as I have stated, not to cover the drops at once, as, if this point be not attended to, the large vacuoles caused by the presence of the ether seriously interfere with the formation of the crystals.

In this manner, the blood of all the commoner animals has been crystallised, the list comprising the blood of the following:

1. Horse.
2. Bullock.
3. Sheep.
4. Pig.
5. Dog.
6. Cat.
7. Rabbit.
8. Squirrel.
9. Guinea-pig.
10. Rat.
11. Mouse.
12. Chicken.
13. Pigeon.

[3] *Physiological Chemistry*, p. 87.
[4] Foster, *Physiology*, 4th edition.
[5] Yeo, *Physiology*, 1884, p. 187.
Landois and Stirling, *Physiology*, 2nd edition, 1886.

which suffices to show that the method has a wide range of applicability. I am quite aware that there are other animals whose blood it would be advisable to submit to the same test, but the exigencies of teaching have prevented the possibility of the expenditure of much time on the work, which has been done at scattered intervals, so that the matter cannot be said to have been by any means completely threshed out as yet. The list, however, practically includes all the domesticated animals whose blood is at all likely to be confounded with that of man, and consequently the value of the method as a comparative one may fairly be said to have been demonstrated.

As a matter of precaution, human blood was subjected to the same test, with the result that usually no crystals could be obtained, although in a few instances they put in an appearance, but, again, with the important difference on which stress has already been laid so much, that when found, they invariably presented the appearances of reduced hæmoglobin, so that the fact of their occasional appearance does not in any way militate against the value of the method.

It will thus be seen that by the employment of the two tests described, we are able to state with certainty, not only that a given specimen of blood is human blood when we find crystals of reduced hæmoglobin as the result of the addition of decomposing serum, but also, if they cannot be obtained in this way, by then treating the blood with ether in the proper manner we may obtain proof positive that it must be blood other than human.

There is yet another method by which human hæmoglobin may be crystallised. Burdon-Sanderson[7] states that "on the addition of a dilute solution of bile-crystals, that is, crystals of glycocholate and taurocholate of soda to blood, a great number of the corpuscles are dissolved, so that the blood becomes distinctly laky, and if it be derived from a suitable source, and not too much diluted, the colouring matter crystallises. On this fact one of the numerous methods of obtaining hæmoglobin (in bulk) is founded." Gamgee[8] gives two methods based on this principle, which, however, he says are not to be recommended. By the injection of a solution of bile-salts into the circulation, also, the corpuscles may be broken up to a certain extent, in consequence of which hæmoglobinuria may result.

Now of course the bile itself is a "dilute solution" of bile-salts, and in the early part of last year one of my assistants in the Physiological Laboratory, Mr. Frederick, made some experiments for me on the action of bile on the blood of various animals, as we were then investigating a most interesting case of biliary fistula which was at that time in the wards of the hospital, under the care of Dr. Bristowe. He found as the result of his experiments that a drop of human blood, when treated on a slide with a drop of bile, preferably cat's bile, usually showed, in the course of a few days, well-marked crystals of hæmoglobin, a fact which I demonstrated to my histology class at the time

On examining the specimens thus formed, I found that here again the crystals were composed of reduced and not of oxy-hæmoglobin; so that it seems perfectly certain that this must be the normal state in which alone hæmoglobin crystallises in man—a point which, as I have before stated, probably accounts for the fact that former observers, who, in accordance with the directions of the textbooks, took care to keep the blood well oxygenated when endeavouring to obtain crystals of the colouring matter, invariably failed in their attempts with human blood.

This method I have not used to any great extent, because the supply of the requisite material, cat's bile, is necessarily somewhat limited; and indeed, although it is very interesting as corroborating some of the points already insisted on, I should hardly have mentioned it, but for the fact that a paragraph appeared, strangely enough, in one of the penny weekly papers, under date January 19th, 1889, to the following effect: "A Spanish physician gives a new method of distinguishing between human and animal blood. Mixed with a little bile small crystals form in the blood, which, in man, are right-angled prisms; in the horse, cubes; in dogs, right-angled prisms, very similar to those in human blood; in sheep, rhomboidal plates; in pigs, rhomboids; and in chickens, more or less regularly, cubes." On inquiry of the editor, it appears that the paragraph was copied from an American paper of date unknown.

It is curious, to say the least, that no mention of the Spanish physician and his work should have appeared in any of the medical papers, and it is difficult to judge of what he may

[7] *Handbook*, p. 179.
[8] *Physiological Chemistry*, p. 86.

have done from a scant paragraph in a lay paper; but if this presents a true summary of his work, we can safely say that it is not of much import. In the first place, as can be seen by preparing a number of specimens of the blood of an animal other than man by any of the methods that have been given, the resulting crystals are not by any means invariable in their shape, although the different shapes present will all belong to the same crystallographic system. According to his own showing, moreover, the crystals from dog's blood are very similar to those in that of man —a point which, if true, would at once condemn the method; while he has apparently not observed what I take to be the point of fundamental importance, the differing degree of oxygenation of the crystallised hæmoglobin in man and in the lower animals.

The methods which up to the present, then, have been successful in demonstrating crystals of hæmoglobin in human blood, and which all agree in the point just mentioned, the presence in the crystalline form of reduced hæmoglobin, may be recapitulated as follows: 1, the addition to the blood of decomposing serum, or, apparently even better, pericardial fluid; 2, treatment with bile; 3, agitation with ether; 4, semi-digestion in the stomach of the common leech; of which the first is the only one to be recommended as being invariably successful.

Thus far I have only spoken of the blood as obtained immediately from the animal; but the methods advocated have possibilities beyond this, although I must candidly confess I do not think that they are capable of demonstration with such infinitesimal quantities as are sufficient for showing conclusively the presence of blood by means of the hæmin test. If the blood be present in fair quantity and has been recently effused, there would be probably no difficulty in discovering whether it is human or not; but, if the quantity be but small, and the stain be not very recent, the difficulty is much increased.

The results of a few experiments copied from my notebook will, perhaps, best show the *modus operandi* and the extent of the capabilities of the methods I propose.

1. Two drops of sheep's blood were placed in a small stoppered specimen tube, three-sixteenths of an inch in width and two inches long, and prepared with ether in the usual manner. After three days preparations, made on slides as described, showed abundant crops of crystals the next day, so that it is obvious that small quantities of blood can be operated with.

2. Two drops of sheep's blood were placed in a specimen tube with twice the amount of water, and prepared with ether as before. Preparations made on slides showed good crops of crystals, so that they can be obtained from minute quantities of diluted blood. This is of importance with regard to the removal of the colouring matter of stains by what would probably be a comparative excess of solvent.

3. A few drops of sheep's blood were purposely spilt on a handkerchief and left to dry. Three days later a small piece of blood-stained rag, about a quarter of an inch square, was cut out and divided into tiny slips. These were placed in one of the tubes with two drops of water until the colouring mater was dissolved out, this being hastened by expression against the side of the tube with a fine glass rod. The bits of rag were then removed, and the resulting infusion was divided into two parts, *a* and *b*; *a* was treated with decomposing serum on a slide, which gave no result; *b* was shaken in a tube with ether after the usual plan, and when what was judged to be a sufficient time had elapsed, a couple of preparations were made on slides, a hair being inserted under the edge of the cover-glass on one side, so as to obtain a thicker stratum of fluid. In these, next day, a scanty crop of crystals was noticed, which appeared, however, quite characteristic, thus showing (what, of course, was known before) that it could not be human blood.

Experiments carried out on the same lines with the blood of other animals, and also with human blood, gave equally successful results. Up to the present, I have not had sufficient opportunity of carrying out an exhaustive series of these experiments; but, from what has been said, it will be seen that in a given stain, at any rate, provided it be fairly recent, it is quite possible to prove the required point.

On theoretical grounds, for I have not as yet been successful in my attempts, we ought to be able to recognise human blood in even old stains almost as well as in recent, for it is well known that after an initial change of most of the oxy-hæmoglobin into meth-hæmoglobin, a stain under ordinary circumstances may undergo no further alteration, even after the lapse of years. It has been shown by Gamgee[9] and other observers that meth-hæmoglobin, at first thought by Sorby to be a per-oxy-hæmoglobin, but more probably a stage in the decomposition of hæmoglobin into hæmatin and a proteid, can[10] be converted by the action of reducing agents into reduced hæmoglobin, the form in which alone the colouring matter crystallises in man, so that we might expect that the addition to the colouring matter of a stain, which had become by age converted into meth-hæmoglobin, of decomposing serum or pericardial fluid, which act as most efficient reducing agents, should be successful in bringing about the formation of crystals almost as well as in the case of more recent blood. In such a case we should have all the proof that was necessary, provided crystals formed, although, as before stated, in the opposite case, we should only be justified in saying that probably it was not human.

Some specimens of putrid serum undoubtedly act much more energetically than others in bringing about the crystallisation of human blood. Whether this be due, at any rate in part, to the stage to which decomposition has advanced, is at present uncertain, but a series of observations is being carried out on the bacteria present in the decomposing serum, and also on certain pathogenic bacteria known to possess reducing powers, the results of which, however, must be left for a future communication.



## REPORT ON THE RELATION OF THE PTOMAINES OR ANIMAL ALKALOIDS TO SOME OF THE INFECTIOUS FEVERS.

By ARTHUR P. LUFF, M.B., B.Sc., F.I.C., F.C.S.,
Lecturer on Medical Jurisprudence and Toxicology, and Warden of the College, St. Mary's Hospital; Assistant-Physician to the North-West London Hospital.

THE object of the research has been to ascertain whether any ptomaines or animal alkaloids are present in the urine of patients suffering from the infectious fevers. Up to the present time I have solely worked on the urine of typhoid fever and of scarlet fever. The process that I have employed for the extraction from the urine of any animal alkaloids that may be present is in many of its details a new one, and has occupied me some time in its elaboration. A large quantity of the urine is rendered alkaline with solution of sodium carbonate, and is then thoroughly agitated with half its bulk of ether; after standing for some time, the ethereal solution is removed, filtered, and agitated with solution of tartaric acid, which settles to the bottom of the vessel, carrying in solution any animal alkaloids in the form of soluble tartrates; the tartaric acid solution is separated from the ether, is rendered alkaline with solution of sodium carbonate, and is again agitated with half its bulk of ether. After standing, the ethereal solution is removed, the ether is allowed to evaporate spontaneously, the residue is dried over strong sulphuric acid, and is then examined for animal alkaloids. The advantages of this method of extraction are: (1) no stronger alkali than sodium carbonate is brought in contact with any animal alkaloid that may be present, (2) no stronger acid than tartaric acid is used, (3) no heat is employed in the process. Judging by analogy with some of the vegetable alkaloids, it is extremely probable that the animal alkaloids would be decomposed by contact with the stronger alkalies and the mineral acids, and also that heat might be a factor in their decomposition. The process employed would therefore offer the best chance of extracting in a pure state any animal alkaloids that might be present in the urine, provided always that they were soluble in ether. Several experiments were made with this process of extraction on normal urines; in no case was anything alkaloidal extracted; the inference is therefore a fair one, that if any animal alkaloid is extracted by this process from the urine of a patient suffering from one of the infectious fevers, that alkaloid has been produced within the system during the course of the fever. I have been extremely careful that all the urines upon which I have worked have been collected from patients who neither previously nor at the time of collecting the urine were taking any alkaloidal or antipyretic medicines. It is on this account that I have been considerably delayed in my researches, especially with regard to

[9] *Physiological Chemistry*, p. 107.
[10] Hoppe-Seyler.

obtaining sufficient quantities of the urine of typhoid fever patients.

I now give an account of the actual results obtained by me up to the present time.

*Urine of Typhoid Fever.*—Patient: female adult. Temperature: 102.5° to 104° F. during time of collection of urine. The urine passed during four days while the fever was its height was collected, and was extracted by the ether process described above. A small quantity of a white crystalline substance was obtained, which exhibited all the properties and gave all the reactions of an animal alkaloid; it was converted into the hydrochlorate by dissolving in very dilute hydrochloric acid, and gave the following reactions:

| | |
|---|---|
| Phosphomolybdic acid | White precipitate |
| Phosphotungstic acid | *Nil* |
| Mercuric and potassium iodide | Dense yellow precipitate |
| Iodine solution | Brown precipitate |
| Tannic acid | Yellowish-brown precipitate |
| Picric acid | Dense yellow precipitate |
| Platinic chloride | *Nil* |
| Gold chloride | Dense yellow precipitate. |

These reactions, as far as I have been able to ascertain, are not given by any previously known animal alkaloids. The substance is probably an animal alkaloid hitherto undiscovered in the urine of typhoid fever.

Patient: Male adult. Temperature: Intermittent, varying from 99.5° F. to subnormal during time of collection of urine. The urine, passed during the twenty-second and twenty-third days of the fever, was collected and extracted by the ether process. No animal alkaloid was obtained.

*Urine of Scarlet Fever.*—The urine was collected from patients at the London Fever Hospital during the height of the fever. Four gallons of urine were extracted by the ether process, and a small but very appreciable quantity of an animal alkaloid was obtained. It was white, semi-crystalline, soluble in water, and faintly alkaline. It was converted into the hydrochlorate by dissolving in very dilute hydrochloric acid, and gave the following reactions:

| | |
|---|---|
| Phosphomolybdic acid | Pale yellowish-white precipitate |
| Phosphotungstic acid | White precipitate |
| Mercuric and potassium iodide | Pale yellowish-white precipitate |
| Iodine solution | Brown precipitate |
| Tannic acid | *Nil* |
| Picric acid | Yellow precipitate |
| Platinic chloride | *Nil* |
| Gold chloride | Slight yellow precipitate |

This animal alkaloid is also, to the best of my knowledge, one hitherto undiscovered. In neither case was sufficient of the alkaloid obtained to allow of its composition being determined by organic analysis. I am at present engaged in extracting a large quantity of scarlet fever urine, with the view of obtaining a further quantity of the animal alkaloid for experiments.

I propose to continue my researches on the urines of typhoid and scarlet fevers, and shall endeavour to obtain sufficient quantities of the animal alkaloids so as to fix their exact chemical composition and constitution by organic analysis and other means.

## THERAPEUTIC MEMORANDA.

### A METHOD OF TREATING PRURITUS AND IRRITABLE SKIN.

PRURITUS, whether occurring as an accompaniment of some other affection, or manifesting itself as a symptom without tangible cause, not infrequently taxes all a practitioner's resources for its relief.

In three cases lately under my care, I have used, with good results, a cone composed of cacao butter impregnated with 2 per cent. of cocaine. This is rubbed over the part affected. The warmth of the skin melts off a layer of the cacao butter, which forms a soothing emollient shield over the irritable patch.

The remedy has been put up in the form of cones, enclosed in boxwood cases with screw-tops, something after the manner of menthol cones.[1] These can be carried about by the patient, ready at any moment for self-application. The boxwood being a non-conductor of heat, prevents the heat of the body from melting the cone whilst it is carried in the patient's pocket.

CASE I.—A feeble gentleman, over 80 years of age, whose rest was disturbed by pruritus ani. Behind the anus was a small patch of chronic eczema, which had been increased by scratching. Oleum deelinæ, cooling lotions, and emollient ointments did little or no good. The cocainised theobroma was the first remedy that gave any relief, although the relief afforded by it was only partial.

CASE II.—In a nearly similar case, that of a clergyman of about 50 years of age, of sedentary habits, the relief afforded was immediate and complete.

CASE III.—A lady who, in addition to shooting pains in the legs, complained of a burning, itching sensation in the front and upper part of the chest. There was no affection of the skin, and no irritating underclothing was worn. There was a suspicion that the pains in the legs were caused by lead-poisoning. In this case the relief the remedy gave was immediate and complete.

In irritable affections of the skin, in cases of insect bite, in pruritus and various forms of hyperæsthesia, the remedy is worthy of trial, and its use has distinct advantages over the more usual applications. Although containing cocaine, I regard the manner in which the cacao butter is spread out over the affected part as having a share in the curative process. It is a method of topical application capable of further development.

NORMAN PORRITT,
Honorary Surgeon, Infirmary, Huddersfield.

[1] Messrs. Reynolds and Branson, of Leeds, have efficiently carried out my wishes, and have prepared the remedy in a very convenient and portable, as well as a cheap and elegant, form.

## OBSTETRIC MEMORANDA.

### QUADRUPLETS.

I SEND you the following short notice of a case of multiple pregnancy which occurred recently in my practice; and as quadruplets are of extreme rarity, it may be of interest as a matter of record if published.

The patient, a collier's wife, aged 35, dark complexioned and of medium size, was first seen by me during the first week of February. She then complained of difficulty of breathing and other symptoms arising from her large size, and the very swollen condition of her lower extremities. Generally she appeared like a person approaching her full term, though her opinion was that she had to go till May. Her heart was weak, with a distinct mitral *bruit*, the lungs slightly emphysematous; the kidneys, considering her condition, acted fairly well, and there was not a trace of albumen in the urine. Her symptoms resisted all our efforts in trying to relieve them, and she continued propped up in bed in a half sitting posture, getting from bad to worse from cardiac dyspnœa till her confinement. On March 5th, about 1 A.M., feeling inclined to micturate, she got herself placed on the utensil, and there, without having had any preliminary labour pains, gave birth to her first child. In an hour the second child was born, and the third and fourth with about a quarter of an hour between each.

It was about half an hour after the last child was born when I reached the house, but I gathered from the nurse "that she tied the cord of the first and second child. The third was born with its placenta attached; and the fourth was born along with the large coalesced placenta of itself and the first two." The first, second, and fourth were girls, and born alive; and, judging by the usual signs of maturity—the nails, etc.—had reached the full term. The fourth succumbed almost directly, the second only lived twenty-seven hours, and the first died in ten days. The third was stillborn, and seemed smaller and arrested morphologically in its development, having its lower extremities so completely webbed that it was not possible to ascertain the sex.

As to the mother, she also succumbed in about six hours after the last birth, from shock, brought on principally through cardiac inadequacy. There was little or no hæmorrhage, and the uterus contracted fairly well. Patient had been married twelve years, and had three previous confinements, all normal.

Ystalyfera. D. THOMAS, M.D.

MYOPIA IN SCHOOL CHILDREN.—Dr. J. L. Miner, of Memphis, Tennessee, has examined the eyes of 682 children in the schools of that town. He found the refraction to be normal in 523, hypermetropic in 128, and myopic in 32. The myopia was found only in children of the fourth class, no less than 15 per cent. of these being affected. His paper is published in the *Memphis Journal of the Medical Sciences.*