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(Plates VIII. to X.)

Of the various synonyms that have been proposed for the parasite, I prefer that conferred upon it by Cobbold, *Bilharzia hæmatobia*, since that name has the merit of commemorating the discoverer, Dr. Bilharz, while it avoids the irregularity of placing an unisexual entozoon in the same genus as the bisexual parasites included amongst the *Distomidæ*, an objection to which the name *Distoma hæmatobium* is open. Harley's name of *Distoma capense* is further objectionable as implying a limit to the geographical distribution of the parasite, since he gave it under the erroneous impression that the animal found by him in patients from the Cape differed from that discovered by Bilharz in Egypt. Diesing's name of *Gynæcophorus hæmatobius* is very appropriate, expressing the most distinctive peculiarity in the creature's anatomy as well as in its life history; but neither this nor any of the remaining synonyms has found general favour, and the name of *Bilharzia hæmatobia* is rapidly superseding all others in the later writings of helminthologists.

Discovery and Geographical Distribution.

Although the hæmaturia symptomatically associated with the presence in man of the *Bilharzia hæmatobia* must have called the attention of many physicians to the disease, and although in various parts of Africa and its neighbouring islands, but more especially in Egypt, the prevalence of a peculiar form of endemic hæmaturia had long been observed,[2] it was not until little more than forty years ago (1851) that

[1] This forms part of an M.D. Thesis, for which a gold medal was awarded in the University of Edinburgh.

[2] Chapotin, Ch., "Topographie médicale de l'Ile de France," Paris, 1812. Salesse, "Diss. sur l'hématurie, ou Pissement de Sang," Paris, 1834. Rayer, "Maladies des Reins," vol. iii. Each of the above authors quotes cases of endemic hæmaturia in the Isle of France, no doubt caused by *Bilharzia*. Todd's description in his work on "Urinary Diseases," 1857, page 62, quoted by Harley, gives an accurate clinical picture of the *Bilharzia* disease, except that no mention is made of the ova, which were doubtless overlooked.

Bilharz, in carrying out, in conjunction with Griesinger, an investigation in regard to the diseases of Egypt, discovered the fact that this hæmaturia was but one of the symptoms of a very formidable helminthiasis due to the presence of a trematode worm and its ova in various parts of the body.[1] In 1857 Cobbold discovered a similar parasite in the portal vein of an African monkey (*Cercopithecus fuliginosus*, or Sooty Monkey), proving it not to be confined exclusively to man. In 1864[2] a paper by Dr. John Harley was read before the Medico-Chirurgical Society of London, announcing the discovery by him in connection with endemic hæmaturia at Port Elizabeth and Uitenhage, in the Cape Colony, of the ova of a parasite to which he then gave the name of *Distoma capense*, but which Cobbold pointed out at the time was no other than the fluke previously described by Bilharz as the cause of the endemic hæmaturia of Egypt. At various times subsequent to this the existence of the parasite has been reported from different places in South Africa by Henderson, Allen, Atherstone, and others in the Cape Colony and Natal, and from Nossi Bi, Madagascar, and Mauritius; as well as by Guillemard and Castle from Central East Africa.[3] I have now to report the same complaint as being very common in the Rustenburg district of the Transvaal (South African Republic), especially along the slopes of the Magaliesberg and Pilandsberg Mountains, and in the valleys of the Eland, Hex, Magalies, and Crocodile Rivers, where a very large proportion of the male population, black and white, are or have been sufferers from it.[4] It seems likely, as our knowledge of the continent and its diseases becomes more precise, that the discoveries of Bilharz and Harley will be gradually supplemented, until the whole length of Africa between Cairo and Port Elizabeth is ultimately included in the territory subject to the ravages of this formidable parasite. The question of the identity of Harley's *Distoma capense* with the *Bilharzia hæmatobia*, if it still admits of any dispute, would be finally settled if it be found that the minute anatomy of the embryo, as described in this paper, corresponds in all its details with that of the embryo of the Egyptian parasite. Differences in the clinical history of the disease in the two countries seem to exist, but they are of degree rather than of kind, and may be accounted for by differences in the climatic conditions to which the parasite is subjected during its development,

[1] Bilharz's account is preserved in the *Zeitschrift für wissenschaft. Zoologie*, Bd. iv., and Griesinger's in his "Klinische und anatomische Beobachtungen über die Krankheiten von Egypten," in the *Archiv f. Heilkunde*, 1856, 12 jahr. s. 1, p. 561. See also "Distomum hæmatobium, und sein Verhältniss zu gewissen pathologischen Veranderungen der menschlichen Harnorganen von Dr. Theo. Bilharz in Cairo," *Wien. med. Wochenschrift*, Nos. 4–5, 1856.

[2] "On the Endemic Hæmaturia of the Cape of Good Hope," by John Harley, M.D., read before the Medico-Chirugical Society, London, 26th January 1864.

[3] R. F. Castle, "Hæmaturia in East Central Africa," *Lancet*, April 25, 1891.

[4] Among the Dutch Boers in these places it is familiarly known as the "Bloedwater" (Blood-water), or "Bloed-graveel" (Blood-gravel).

or more probably by distinctions in the racial characteristics of its human hosts.

Etiology.

The manner in which the *Bilharzia* gains access to the human body still remains uncertain, in spite of many attempts by such able inquirers as the late Spencer Cobbold of London [1] and Prospero Sonsino of Pisa [2] to follow the subject out experimentally as well as clinically. Our knowledge of the stages of its development from the embryonic condition to its mature state, unlike that in regard to the other trematode worms, is almost nil. As yet, therefore, we can only go upon hypotheses, of which there are several, chiefly founded upon analogy drawn from the life history of other trematodes, which, in completing their genetic life cycle, take up a temporary abode in water as free swimming embryos, or in the bodies of various invertebrate hosts, before they find an environment congenial to them in their mature condition.

Griesinger suggests (*loc. cit.*) that the larvæ of the *Bilharzia* exist in the river water and in the fishes frequenting it, or even in bread, grain, or fruit. Cobbold thinks it more probable that they will be found in gasteropod molluscs (in the form of cercariæ, rediæ, and sporocysts) proper to the localities from whence the adult flukes have been obtained, and that it is by the ingestion of these adhering to edible vegetables that infection is prone to occur.[3] Sonsino thinks that everything would tend to prove that the worm gains access to the human subject by means of impure drinking water, in which the larvæ exist, either in a free state or embedded in other organisms which are swallowed with the water, a view he claims to rest upon two orders of facts :—

1. That the embryo when expelled from the human body being ciliated, offers the very best conditions for aquatic locomotion, and thus may reasonably be supposed, by the medium of water, to gain entrance to the body of a host suited to its subsequent transformations.

2. That whereas the agricultural class in Egypt, who are in the habit of drinking the impure water of stagnant pools or running streams, are greatly subject to infection from the parasite, the inhabitants of Cairo, who generally make use of purified water, are less frequently affected, while the disease is very rare among the European community who filter the water before using it.

The same observer puts forward with much plausibility the contention, also upheld by Harley, that, infection having once taken place, the disease may be continued by so-called auto-infection, exceptional

[1] T. Spencer Cobbold, "On the Development of *Bilharzia Hæmatobia*." Read before the Metropolitan Counties Branch of British Medical Association, 17th May 1872.

[2] P. Sonsino, "Ricerche sullo sviluppo della Bilharzia," *Giornale della R. Accademia di medicina di Torino*, Agosto 1884.

[3] T. Spencer Cobbold, "Entozoa : an Introduction to the Study of Helminthology," 1864, p. 36.

circumstances enabling the embryo to remain and complete its various stages of development in the original host.

The theory of infection by drinking water finds many adherents. Fritsch [1] asserts that of all the possibilities put forward there remains but one which obtains wherever the worm shows itself, viz., the use of impure drinking water, particularly from stagnant pools. Harley (*op. cit.*), Allen, and others have suggested the possibility that the larvæ find entrance during bathing by the small superficial veins or by the urethra or rectum.

My own inquiries on this point have led me to the conclusion that bathing is, in this neighbourhood, at any rate, the most fruitful source of the infection. I cannot, among several hundred instances, recall one exception to the rule that all who suffer from the parasite have been in the habit of bathing. Moreover, it is among boys, who are fondest of swimming, that the symptoms earliest make their appearance; and I believe it would be hard, if not impossible, to find one boy much given to bathing in the streams above mentioned, or their tributaries, who does not, before reaching manhood, become a subject of the disease. Only on this theory is explicable the fact noted by various observers in South Africa that the female sex is rarely attacked by *Bilharzia*. If it be the case, as Sonsino [2] so positively states, that females are quite as liable as males to contract the disease, it is difficult to explain in any other way the almost total immunity which the female sex actually does enjoy in this district. Among the many patients with *Bilharzia* whom I have treated here in the last three years, there is not one of the female sex; and only once or twice have I heard of cases of hæmaturia in females, which probably had their origin in the presence of the parasite. It cannot fairly be urged, as is done by Fritsch, that this difference in frequency in the two sexes is due to the greater purity of the drinking water used by females, for, at the early age at which *Bilharzia* is commonly contracted, boys and girls are placed under much the same conditions as regards the quality of water which they drink. But in the use of water for bathing it is otherwise. The country population of this district consists almost exclusively of Boers, who, in the Transvaal, are very negligent about personal cleanliness. Neither sex, indeed, ordinarily washes more than the hands and feet for the purpose of cleansing, and the Boer girls rarely indulge in bathing. The boys, on the other hand, are constantly in the water, often remaining in it for hours at a time during the warm days of summer, a season when the larvæ of the *Bilharzia* are presumably most active. Newcomers, even if they are adults, who venture to bathe frequently in the streams, soon contract the disease, while others who avoid doing so escape. The immunity in the latter case may, however, be the result of

[1] Gustav Fritsch, "Zur Anatomie der Bilharzia Hæmatobia" (Cobbold), *Arch. für mikroskop. Anat. Bonn*, January 1888, Bd. xxxi. Heft 2.

[2] P. Sonsino, "La Bilharzia hæmatobia et son rôle Pathologique en Egypte," *Arch. gén. de méd.* Juin 1876.

care in other respects, as those who are aware of the danger naturally avoid every suspected source of infection.

That the drinking of impure water is a common factor in the process of infection, there is no lack of evidence; indeed, it would be unreasonable to think otherwise if the bathing hypothesis be well grounded. But, other things being equal, the chances of infection occurring will be greater from the large quantity of water which must come in contact with the body in bathing, than from the comparatively small amount conveyed into the stomach by drinking; so that, granting the larvæ to have the power of penetrating the body by some means, we should expect to meet with a much larger proportion of cases among bathers than among those who only drink the infective water.

In connection with this I may mention that those who bathe in the stream skirting the town of Rustenburg complain of severe itching on emerging from the water. I have never had any occasion to notice the occurrence here of the superficial sores described by some, and attributed by them to the irritation caused by attacks of *Bilharzia* larvæ. Here, as elsewhere in South Africa, there are cases of boils and sores due to larvæ, but those I have known have been from the larvæ of a species of musca, which lays its eggs in the skin of children, and there is no evidence that persons suffering from *Bilharzia* have been affected with boils and sores more than others.

My inquiries into the *manner* of infection of the *Bilharzia* have not led me to suspect the presence of the larvæ in grain, vegetable salads, or fruit. Wheat and very large numbers of oranges are exported from this district to Kimberley, Johannesburg, and Pretoria, without, so far as I have heard, ever carrying the disease thither, while salads are rarely used by the Boers, among whom the disease is so common.

There is no evidence whatever that infection can take place by direct contagion. It has, for example, never been known to have been conveyed by a husband to his wife.

The question of how infection occurs will, however, only be satisfactorily solved when we have succeeded in tracing the development of the parasite through all its stages. Unfortunately very little progress has so far been made with this problem, as it presents at its very outset difficulties that have baffled the ingenuity of the most accomplished helminthologists.

Anatomy of the Bilharzia Hæmatobia.

A. The ovum.—The ova of the *Bilharzia* may be seen in the ovisac of the mature worm, but I have only been able to study them as they appear in the urine of patients suffering from *Bilharzia*. In this situation they may, however, be seen in all stages of development, and in enormous numbers. They lie embedded in thousands in the clots of blood (Plate VIII., Fig. 1) and in the mucus,[1] so often passed in this

[1] See Harley, *Med. Chir. Trans.* vol. xlvii. plate i. figs. 1 and 2.

disease from the urinary passages, and they are also found plentifully lying free in the urine.

The most immature ova have a simple envelope with a short spine at one end, and are filled with granules of various sizes. They are about $\frac{1}{400}$ in. in length and about $\frac{1}{600}$ in. in breadth (Plate VIII., Fig. 2).

In older specimens segmentation may be seen in different stages, and by searching among the ova one may trace step by step their development from the simple chaotic granular mass, represented in Plate VIII., Fig. 2 *a*, through various stages until the embryo attains the very definite and comparatively complex structure shown in Plate VIII., Figs. 4 and 5.

The fully-matured ovum has usually the shape of a hen's egg, and measures from $\frac{1}{180}$ in. to $\frac{1}{160}$ in. in length, and about $\frac{1}{325}$ in. in breadth. There is, however, much irregularity noticeable even in mature specimens, both in size and in shape. Some are a little larger, others a good deal smaller, than these measurements, and some are long and narrow, while others are shaped more like a pear or a boy's kite (Plate VIII., Fig. 3).

The outer envelope or shell is so clear and smooth as scarcely to interfere at all with our view of its contents. By reflected light it appears shiny and of a brownish or pinkish neutral tint. It is soft and delicate and very thin, but its double contour can readily be made out under a high power (Plate VIII., Fig. 4 *a*). At the narrower end of the egg, there is placed a sharp projecting spine (Fig. 4 *b*) of varying length, into which the main cavity of the shell is generally continued. This spine, often very short, is sometimes altogether absent. Its average length is about $\frac{1}{2000}$ in., or one-tenth of the total length of the egg. According to Cobbold,[1] it is the homologue of a very much larger structure in certain other trematode ova, where it serves as a "holdfast," by which the eggs attach themselves to the body of their host. In the *Bilharzia* its use for this purpose, if it have any, must, from its straightness and trifling length, be very slight. In eggs which have been voided through the rectum it is said[2] that these spines are often placed laterally (Plate IX., Fig. 12; see also Sonsino's Plates). I have never been able to observe this, and can confirm Harley's assertion that those from the urinary passages never present this peculiarity.

[1] T. Spencer Cobbold, "On the Development of *Bilharzia Hæmatobia*." This paper contains the most accurate account of the ovum which I have been able to obtain. No mention is made in it, however, of several important points in the anatomy of the ovum, as for instance the lateral excretory apertures and the four contractile organs, structures which I believe I am now the first to describe. The measurements of certain parts of the ovum made by Cobbold I have accepted as correct, and added to my description to make it more complete.

[2] "Organs and Parasites from Cases of *Bilharzia*," *Report of Path. Soc. of London*, 16th April 1889; *Brit. Med. Journ.* 20th April 1889. Article on "Bilharzia Hæmatobia," by V. Belleli, in *Le Progrès médical*, 25 Juillet 1885, p. 54. P. Sonsino, "Ricerche sullo sviluppo della Bilharzia Hæmatobia," *Giorn. R. Acc. di Med. di Torino*, Agosto 1884. P. Sonsino, "La Bilharzia Hæmatobia et son rôle Pathologique en Egypte," *Arch. gén. de méd.*, Juin 1876.

Lining the interior of the shell, and intervening between it and the embryo, is a delicate granular membrane (Plate VIII., Fig. 4 *c*), best seen during and after the extrusion of the embryo (Plate VIII., Fig. 6 *m*). The space (Plate VIII., Fig. 4) between this granular membrane and the embryo varies much in width according to the size of the latter, and shortly before the rupture of the shell becomes filled with numbers of bright granules (Plate VIII., Fig. 5 *g*); these are extruded from the interior of the embryo through certain lateral apertures presently to be described. They exhibit Brunonian movements, and are often agitated by the action of the cilia with which the body of the embryo is covered.

The embryo (Plate VIII., Fig. 4 *e*), until the time draws near for its obtaining its liberty, lies quiescent in its shell, only now and then moving its head from side to side, or occasionally drawing its whole body upwards with a jerking movement. A cursory glance shows what at first appears an almost structureless sarcodic mass, roughly corresponding in shape to the surrounding envelope. Closer examination, however, shows this apparently simple mass to be a creature of considerable complexity of structure.

The cephalic end of the embryo (Plate VIII., Fig. 4*f*), which is sometimes placed at that end of the shell which terminates in the spine, and sometimes at the other (Plate VIII., Fig. 3), is distinguished from the caudal end by its shape, which is that of a truncated cone with the extremity further prolonged into a kind of snout, the oral papilla (Plate VIII., Fig. 4 *f*). The whole body, with the exception of this papilla, is covered with cilia (Plate IX., Fig. 7) arranged both longitudinally and transversely in beautifully regular lines. The regularity of their arrangement is only interrupted at two places by the two coronal series of apertures (Plate VIII., Fig. 5, and Plate IX., Fig. 7, *a* and *b*) to be afterwards described, which divide the surface of the body into cephalic, caudal, and intermediate zones. Close to the base of the papilla the cilia are very short, but further back they gradually increase in length, until, at a point where the anterior series of apertures open, they reach their extreme length of about $\frac{1}{2000}$ of an inch. The cilia of this cephalic zone are stronger and more active than those of the intermediate and caudal zones. They are nearly always in motion, even before the embryo escapes from the shell, and are the last to retain their movement when the embryo is dying. Those of the caudal and intermediate zones are pretty uniform in length, very delicate, and easily injured. One circular row of filaments standing straight out from the body, vibrating slightly, or more usually quite motionless, may generally be seen at the lines of junction of the intermediate with the other zones. These filaments are probably not cilia, but the remains of the ligaments by which the embryo was attached to its envelope.

Both the envelope and the body substance of the embryo are very transparent, so that no obstruction is presented by them to a complete view of its interior. The transparency of the various parts is indeed so

great as to become rather a hindrance than a help in discovering their disposition and relations. With care most of them are distinguishable, even before the shell is discarded, and by the examination of many different specimens, both in and out of the shell, I have been able to obtain satisfactory views of nearly every detail.

Before speaking of the structure of the interior of the body, I must first refer a little further to certain orifices on its exterior. The mouth of the embryo is placed in the centre of the oral papilla (Plate VIII., Fig. 4 *f*). At the extremity of the caudal end, where the anus might be looked for, a slight depression (Plate VIII., Fig. 4 *l*) is generally to be found. I have not been able to find any connection between it and the alimentary canal, and have never seen anything being extruded from it. It is probably, therefore, only a rudimentary structure; or it may be that it is an open "foramen caudale," as the water vascular system of vessels of the two sides are connected with one another very close to it. The function of an anus seems to be performed by the two series of lateral apertures (Plate IX., Fig. 7, *a* and *b*), already referred to. These are placed coronally at about an equal distance from each pole of the embryo and from each other, the distance, however, varying a good deal in different specimens. The apertures of the anterior series (Plate VIII., Fig. 5, and Plate IX., Fig. 7 *a*) merge into one another externally, so as to form a coronal slit in the ciliated covering of the organism into which the excretory ducts probably open. The posterior series (Plate VIII., Fig. 5, and Plate IX., Fig. 7 *b*) is much more distinct, and consists of some thirty apertures, between each of which stands a single large filament. From both series globules and granules are often seen being extruded (Plate VIII., Figs. 4 *d*, 5 *a* and *b*, and Plate IX., Fig. 11). The granules previously mentioned as filling the space in the ovum between the embryo and its inner or membranous envelope (Plate VIII., Fig. 5 *g*) are chiefly, if not entirely, so derived. The globules as they emerge may frequently be seen clinging to the sides of the embryo on or between the cilia situated near the apertures. Plate X., Fig. 14, also shows, very highly magnified, various of the foregoing objects.

These lateral apertures on the embryo have not been noticed by any other observer, so far as I am aware. Nothing similar to them is mentioned by Cobbold as existing in any of the embryos of the other entozoa.

The body of the *Bilharzia* embryo consists of contractile protoplasm, through which refractile granules and globules of various sizes are interspersed. It is furnished with a digestive and a water-vascular system, and contains other structures, the function of which is not clear. There is a distinct œsophagus (Plate VIII., Fig. 4 *g*, and Plate X., Fig. 14, etc.), terminating anteriorly at the oral papilla in a somewhat dilated funnel-shaped end with transverse markings upon it, which give it the appearance of being ringed, and entering posteriorly the large stomach (Plate VIII., Fig. 4 *h*), which occupies part of the middle

division of the embryo, and terminates behind in a wide tube. This tube (Plate VIII., Fig. 4 *i*) is very indistinctly differentiated from the surrounding sarcode, and consequently is very difficult to trace. After a very short course, indeed, almost immediately on leaving the stomach, it appears to bifurcate. This appearance of bifurcation I have observed in so many specimens that I feel pretty sure of its actual occurrence in all cases. I cannot say what becomes of the branches into which the tube divides, but considering the manner in which excretion takes place, it is at any rate unlikely that they terminate in a single anus at the posterior extremity of the body. In one specimen I saw the appearance represented in Plate IX., Fig. 11, where the branches seem to run back nearly to the tail, approaching one another posteriorly as if about to reunite. Here they unfortunately became so indistinct that it was impossible to trace them further.

The presence in the embryo of a water-vascular system was noticed and described by Cobbold (*loc. cit.*).[1] Without being aware of this, I had satisfied myself of its existence, and made out with great distinctness in many specimens all that he there describes, besides certain other points of great interest which he appears to have overlooked. The water-vascular system is best seen after the embryo has escaped from the shell and has been swimming about for some time in water. It begins in the oral papilla, around the base of which there seems to be a circular vessel; one branch passes down either side of the body until the two meet and unite near the depression previously noticed at the caudal extremity (Plate VIII., Fig. 4 *o*, *o*, *o*). In their passage downwards they give off several anastomosing branches which ramify over the whole body of the embryo, but which specially concentrate and arrange themselves around four particular points (Plate VIII., Fig. 4 *k*,*k*,*k*,*k*) placed in pairs, one pair lying in the anterior half, the other in the posterior half of the body. If the embryo be alive there will always be seen at these four points a rhythmical contractile movement, varying in rapidity from one to three or even more beats per second. The movement appears to take place in a short tube near the dorsal [2] surface of the embryo, and it is rapid or slow according as the embryo is lively or the reverse. It has nothing to do with the movement of the cilia, which are often quiescent while the contractile organs are active. The members of each pair are situated symmetrically on either side of the body, about $\frac{1}{600}$ in. apart, those of the anterior pair usually lying in the middle division of the embryo in the interval between the sides of the stomach and the two pyriform masses to be described later, and those of the posterior pair in the caudal division a little way behind the plane of the posterior series of apertures (Plate X., Fig. 14).

[1] *Ibid. ante*, p. 59.

[2] For convenience I have termed that aspect of the body near to which the digestive canal lies the ventral aspect, and that near which the stalked masses lie, the dorsal aspect. (See Plate X., Figs. 15, 16, and 17.)

Placed in the centre of a complicated network of tubes, and exhibiting such well-marked contractile movements always in a constant definite direction, these organs can hardly be other than circulatory in their function, probably serving to propel a nourishing fluid through the water-vascular system, and perhaps also to establish communication between that system and the fluid in which the embryo swims. An appearance can often be seen of a short tube passing from each contractile organ to the nearest lateral aperture, the anterior pair of contractile organs apparently communicating with the anterior series of apertures, and the posterior pair with the posterior series. I have, however, entirely failed to detect any circulation either in the tubes immediately surrounding the contractile organs, or in any of the numerous branches of the water-vascular system which are distributed elsewhere in the body; but this failure I attribute to the transparent character of the circulating fluid.

The most prominent of the structures in the interior of the embryo yet remain to be described, namely, two rounded masses (Plate VIII., Fig. 4 *m*) lying in the anterior half of the embryo, one on either side. Their shape is often pear-like (Plate IX., Fig. 10), and they were therefore called by Cobbold "pyriform bodies," but they are more usually rounded (Plate VIII., Fig. 4 *m*), or irregularly quadrilateral in contour, frequently with a notch on their posterior border (Plate IX., Fig. 9). They are roughly granular bodies, measuring $\frac{1}{2500}$ in. in diameter with a bright double outline, and containing in their interior one or more prominent nuclei (Plate X., Fig. 14). They are situated one on either side of the stomach about the junction of the anterior and middle thirds of the body, nearer to the dorsal than the ventral aspect of the latter (Plate X., Fig. 16). From their anterior and outer side two stalk-like processes (Plate X., Fig. 4 *n*) pass forward one on either side of the œsophagus, which has just room to pass between and below them, to terminate in two small points projecting slightly beyond the surface of the integument in the sides of the oral papilla. These stalk-like processes have been described by Harley as tubes, but I have not been able to make out any appearance of their being hollow, and believe both them and the masses from which they spring to be solid structures. They are of much firmer consistence than any other part of the embryo, and are often seen lying with the masses attached, outside the body of the embryo, when the latter has been injured and ruptured by pressure on the cover glass. The masses are also very easily displaced from their natural positions, the least rough usage of the embryo serving, as it were, to dislocate them. It is difficult to imagine what the function of these structures may be, and their morphological significance is equally obscure. It may be that the peduncles are muscular organs, helping in the movements of the head and giving more rigidity to the "neck." I find these two pedunculated masses invariably present in the mature ovum. Cobbold speaks of them as varying in

number, but he was probably looking at them in profile when he saw only one (Plate IX., Fig. 11, and Plate X., Fig. 16), and indeed his whole description gives only a vague idea of their position and relations (Plate X., Figs. 15, 16, and 17).

After the mature ovum is voided with the urine, certain changes go on in it, resulting in the rupture of the envelopes and escape of the contained embryo. The cilia of the cephalic zone first begin to move rapidly, and the creature pushes and turns its head about in all directions, as if endeavouring to free itself from the attachments which exist between it and the inner envelope, opposite the junctions of the zones, and which are especially strong anteriorly, where the cephalic joins the intermediate zone. At the same time numbers of granules and globules of various sizes, as also probably fluid, are poured out from the lateral apertures into the space between the embryo and the inner envelope, so as to distend it, and so assist in the separation of the attachments. All the cilia are soon at work creating a great commotion amongst these particles, vigorous contractions of the body taking place the while, by means of which the latter is considerably increased in breadth, and presses upon the sides of the shell. The oral papilla is also used with great vigour as a proboscis to rub against the investing membrane in all directions, the creature twisting itself about, drawing itself up, and even turning complete somersaults in the shell (Plate IX., Fig. 10). The shell meanwhile grows thinner and thinner and more delicate, until at last there occurs a longitudinal lateral rupture, by which the embryo promptly emerges, presenting indifferently by the cephalic or the caudal end (Plate VIII., Fig. 6 *a*). The membranous envelope either remains behind in the outer shell (Plate VIII., Fig. 6 *a m*), or protrudes through the slit (Plate VIII., Fig. 6 *b m*). If the urine be not highly saline, or have previously been replaced by pure water, the escaped embryo, relieved from the confining pressure of the shell, assumes its natural elongated "torpedo" like shape, and swims away with great rapidity (Plate IX., Fig. 9). If the weather be cold, or there be much impurity in the surrounding fluid, or the embryo have been prematurely extruded, strange and unnatural shapes are assumed (Plate IX., Fig. 8 *a*, *b*), a very common form being that of an hour-glass (Plate IX., Fig. 8 *a*).

The time required for hatching varies very much according to the state of development of the embryo, and also according to the temperature to which the latter is exposed after being voided with the urine. It may occur within a few hours, or be delayed for several days.

Cobbold, Sonsino, and others have made many attempts to keep alive the liberated embryo, with the object of tracing its development; but after a few days, and before, as a rule, any great change had taken place, the death of the animal defeated the inquiry. Moiniez[1] states that very soon larvæ make their appearance by means of a sort of internal budding

[1] R. Moniez, M.D., "Human Parasites." Paris, 1889.

in the embryo, which dies and is ruptured in order to be delivered of them. But reasoning from analogy, it appears most probable that the larvæ become encysted in or on some aquatic animal, possibly passing through more than one phase and one host before attaining their perfect development in the human system. They have been experimentally brought in contact with different species of fishes, mollusca, crustaceæ, larvæ of insects, etc., but have in no instance been found to attack any of them.

B. The adult worm.—As I have been unable to procure any specimens of the adult *Bilharzia*, it has not been possible for me to make any original observations upon its anatomy. The subject has, however, been exhaustively worked out by Bilharz,[1] Leuckart,[2] Küchenmeister,[3] Cobbold,[4] Sonsino,[5] and others,[6] and lately very fully by G. Fritsch in the article already quoted. I shall, therefore, confine myself to a short description taken from these authors of the animal's chief anatomical features and peculiarities.

The *Bilharzia*, as already stated, differs from all other *Distomidæ* in that the male and female reproductive organs occur in separate individuals. The broad posterior portion of the body of the male worm is rolled or curled all along its length, so as to form a cylinder with an open longitudinal groove or passage on the ventral aspect for the reception during congress of the body of the female, which is embraced by its middle portion, the extremities of her body, especially the posterior, projecting considerably from either end of it. It is in this position that the two sexes are usually found in the adult stage; but occasionally a male is found alone, or more rarely a female, for after fecundation the latter leaves the male and finds its way into the minute blood vessels of the intestinal and vesical walls, there to deposit its eggs. The male, owing to its greater bulk, cannot do this.

The male is white in colour, usually about half-an-inch long, and as thick as an oxyuris. Its body is covered everywhere, except near the anterior extremity and gynecophoric canal, with microscopic tubercles. The female, though nearly half as long again, is no thicker than a very fine silk thread. Its body, especially posteriorly, has fine prickle-like projections, and is of a dark colour. Both male and female are provided with two suckers, of which the anterior constitutes the buccal cavity, whilst the ventral one serves as an organ of fixation. The alimentary canal is unlike that of the other *Distomidæ* in this respect, that the bifurcated intestine, instead of ending separately in two blind extremities, as is usually the case in that genus, reunites posteriorly to terminate in one single one,[7] which in the female, after running spirally down the body, terminates blindly near the point of the tail, but in the male opens near the posterior extremity of the body at a minute excretory pore. The genital organs

[1] Bilharz, (1) "Distomum hæmatobium und sein Verhältniss zu gewissen pathologischen Veranderungen der menschlichen Harnorganen," *Wien. med. Wochenschrift*, Nr. 4-5, 1856; (2) "Brief von B. von Siebold," *Zeitschrift für wissenschaft. Zoolog.* Bd. iv.

[2] Leuckart, "Die menschlichen Parasiten."

[3] Kuchenmeister, "Die thierischen Parasiten der Menschen," Theil i. p. 340.

[4] Cobbold, (1) "Parasites of Man"; (2) "On the Development of *Bilharzia Hæmatobia*," *Brit. Med. Journ.* May 1872.

[5] Sonsino, *op. cit.*

[6] Kartulis, "Ueber das Vorkommen der Eier des D. hæmatobium in den Unterleibsorganen," *Virchow's Archiv*, Bd. xcix. p. 139.

[7] Fritsch, *op. cit.* But other authors have not observed this reunion in the male worm.

are very elementary, consisting, in the male, of the testes and seminal vesicle (?), placed not far from the ventral sucker, with a duct opening in the bottom of the gynecophoric canal near its anterior end, and in the female of vitellarium and germarium, the former placed on either side of the termination of the intestine, the latter situated further forward at the point where the two branches of the intestine rejoin to form a single tube. The vitelligene and germigene canals from these combine in a single oviduct which, running forwards, expands to form the uterus. The ova are generally to be seen in a single or double row arranged along the oviduct. The external opening of the genital apparatus, placed close to the posterior margin of the acetabulum, communicates by a short tube with the uterus, of which indeed the tube is but the contracted forward continuation. The spines of the ova are directed backwards so as to form no obstacle to the free progress of the egg along the oviduct (Sonsino). The minute anatomy of both sexes is very fully described by Fritsch in the article referred to, to transcribe which would, however, be superfluous here.

Pathological Effects.

The adult worm is found most frequently in the portal vein and its branches and roots, *e.g.* the splenic, and in the vesical veins, adhering to the inner coat of the vessels, or in the blood-clots contained in them post-mortem. Sonsino has only once found it in the vesical veins.[1] It does not appear that the parasites themselves by their presence cause much trouble; it is their eggs which directly give rise to the lesions in various organs which have been observed in connection with the *Bilharzia* helminthiasis.

The fact of the adult worm being found in the portal vein is a strong proof of the truth of the hypothesis that at anyrate one method by which the animal finds entrance to the body is through the stomach. The occurrence of the worm in the systemic as well as the portal circulation may be explained by the different anastomoses which exist between the two systems, especially the free anastomosis in the rectum between the hæmorrhoidal branches of the inferior mesenteric root of the portal vein, and the middle and superior hæmorrhoidal branches of the internal iliac; or it may be, as Harley first surmised,[2] that the larvæ enter the systemic circulation directly by the superficial veins during bathing,—a method of infection which my own inquiries have led me to think highly probable. Why the abdominal veins in that case should alone lodge the parasite it is difficult to understand, but it is also hard to see how the eggs of worms that have been introduced by the portal system should find their way mainly to the urinary tract, whose circulation is only connected by small anastomosing vessels with that system. Harley has also suggested that the larvæ may enter the bladder directly through the urethra during bathing. However this may be, it seems certain that once in the blood the female worm, after fecundation, finds her way into a small vein, where, becoming encysted,

[1] P. Sonsino, "La Bilharzia Hæmatobia et son rôle pathologique en Egypte," *Arch. gén. de méd.* Juin 1876.

[2] Quoted by Hilton Fagge in his "Principles and Practice of Medicine," vol. ii. p. 703.

she lays her eggs in such abundance that the vein is burst, and the eggs set free into the tissues or cavities in its neighbourhood. The organs in which most eggs are found post-mortem are — the bladder, ureters, vesiculæ seminales, mesenteric glands, and rectum. They have also been found in the liver, kidneys, and prostate, by Kartulis,[1] in the lungs by Mackie and others,[2] and even in the left ventricle of the heart by Griesinger. The cavities into which they escape most generally are those of the urinary apparatus,—pelvis of kidney, ureters, and bladder,—when they of course mix with the urine and are mostly passed with it; but they also escape into the rectum to be passed out with the fæces. When the ova thus break through the mucous membrane into any of these cavities, the rupture is accompanied by hæmorrhage, which is sometimes the only symptom noticed by the patient, while it is always the most constant and most noticeable of the clinical phenomena of the *Bilharzia* disease, giving it the name, by which it was formerly vaguely known, of endemic hæmaturia. Among the more ignorant of the Boers of this district, it is not uncommon to hear the complaint referred to as if the appearance of blood in the urine of boys were little more than a physiological fact, to be expected as a matter of course.

By Bilharz[3] the anatomico-pathological effects, caused by the eggs of the *Bilharzia*, have been divided into three varieties—(1) induration; (2) polypoid vegetation; (3) ulceration. Of these, the last is rarely met with, except as small erosions visible by the aid of a simple lens. By Sonsino[4] six types are enumerated under the generic name of infarctions, "*infarctus vésiculaire, hæmorrhagique, granuleux, avec incrustation, ulcéreux, végétant.*" In the rectum, on account of the vascularity of its mucous membrane, he finds only the hæmorrhagic form and vegetations; in the bladder the granular (termed by Bilharz the "sandy"). In the ureters and vesiculæ seminales the granular form is common, whilst the vesicular is usual in the bladder and ureters. Incrustations of carbonate of lime are frequent on the shells of the ova.[5] In the numerous autopsies made in Egypt by Bilharz and Griesinger,[6] the chief seat of pathological changes was found to be the bladder, but these changes also frequently extended to the ureters, and even to the substance of the kidneys. They consisted in the formation of infiltrated congested and ecchymosed patches, varying in size from a quarter to half an inch in diameter, covered over with slimy

[1] Kartulis, *Virchow's Archiv*, 1885, Bd. xcv.

[2] C. H. Eyles, *Lancet*, 1st October 1887, p. 659; and Albert Renault in *Le Progrès médical*, 25th July 1885, p. 57.

[3] Bilharz, "Distomum Hæmatobium und sein Verhältniss zu gewissen pathologischen Veränderungen der menschlichen Harnorganen," *Wien. med. Wochensch.* Nos. 4, 5, 1856.

[4] *Op. cit.*

[5] P. Sonsino, "La Bilharzia Hæmatobia et son rôle pathologique en Egypte," *Arch. gén. de méd.* Juin 1876.

[6] *Op. cit.*

mucus or soft yellow exudation, and placed most frequently, sometimes exclusively, on the posterior portion of the mucous membrane of the bladder. Often a thick, soft, granular material, usually with an incrustation of lime salts, had become deposited in the mucous membrane, which was itself often affected with a chronic inflammation, or had become the seat of warty outgrowths or vegetations. The appearances in the ureters and renal pelves were similar, but in them the effects were much more serious, often resulting, owing to obstruction to the flow of urine, in pyo- or hydro-nephrosis, and even in destruction of the renal substance itself. In the bowel, similar changes were observed. During life these lesions had given rise to symptoms of chronic inflammation of the mucous membrane, taking the form, in the case of the urinary organs, of cystitis or pyelitis, and in the case of the intestine of diarrhœa or a kind of dysentery.

The presence of foreign particles, such as the ova of the *Bilharzia*, in the bladder and pelvis of the kidney, leads, as might be expected, to concretions being formed by precipitation of the urinary salts, normal and pathological, upon them. In the calculi thus originated, a careful examination will usually discover a nucleus of *Bilharzia* egg-shells. I have been able to verify this fact in two instances with stones passed after attacks of renal colic. Sometimes calculi of very large size, so originated, have been found in the bladder both during life, and post-mortem.

New growths—papillomata, adenomata, and even cancer—also occur in the rectum and bladder, presumably caused by the irritation of the *Bilharzia* eggs, the shells of which have been found embedded in them.

It is not surprising that the exhaustion and other grave effects brought on by such lesions should lead in many cases to a fatal result. In Egypt this happens frequently, the direct cause of death being usually pneumonia or dysentery, the former probably septic in origin. In South Africa the pathological changes have not been sufficiently investigated owing to the difficulty of obtaining autopsies, but they are doubtless of a much less severe kind than those met with in Egypt, since they appear very rarely to cause death.

Symptomatology.

The passage of blood, *per urethram*, is usually the first intimation to the patient invaded by the *Bilharzia* that he has become affected; although sometimes uneasy sensations, seldom amounting to pain, are complained of in the lumbar regions or about the perinæum, before any blood is noticed. As the patient is usually a child, the disease may have been present a long time before attention is called to it by the detection of blood (which is perhaps first noticed on the child's clothes), and it is thus often impossible in any given case, not only to say when invasion may have taken place, but even to fix

the date on which the first outward manifestations of the disease made their appearance. The period required for the helminthiasis to develop to such an extent as to cause hæmaturia is thus difficult to determine with precision. It probably varies in different cases according to the individual attacked, and the number of parasites present. From observations on some cases of adults, who were attacked after their arrival in the district of Rustenburg, I have gathered the impression that a period of four months is sufficient. The blood is not as a rule mixed uniformly with the urine, but is almost always passed at the end of micturition, the quantity varying from a few drops to a tea- or even a tablespoonful. After exertion, such as lifting heavy weights, running or dancing, or after riding on horseback, the amount is markedly increased. In some instances all the urine is deeply tinged with blood, but in such the last passed always contains most. The blood would thus seem to be chiefly vesical in origin. It may be fresh and brightly coloured, or dark, and it often passes in clots which fill the urethra, and only come away with difficulty. After attacks of renal colic, clots may be noticed that from their form have evidently come from the ureters. In some cases again, there is so little blood in the urine that it can only be seen by means of the microscope. Lastly, the hæmaturia may be intermittent, blood appearing perhaps only after some unusual exertion.

A long time may elapse before pain becomes a prominent symptom, but eventually this usually happens. It is chiefly caused by the passage along the ureters of lumps of mucus, pieces of congealed blood, or, in cases of long standing, of small calculi which have formed in the renal pelves. Dull aching pain, or less frequently sharp shooting pains, may be complained of. They may be felt in the small of the back, in the kidney region, over the course of the ureters, in the bladder, or along the urethra, and are doubtless the accompaniment of the irritation and inflammatory mischief produced by the parasite and its eggs in these organs.

Irritability of the bladder is a frequent symptom, and micturition is generally preceded and accompanied by a burning sensation, and followed by a feeling of smarting and straining.

When severe and long continued the disease gives rise to catarrh of the urinary tract, evidenced by the presence of quantities of mucus in the urine; and, later still, the more serious symptoms of cystitis, inflammation of the mucous membrane of the ureters, and pyelitis, are apt to develop. These affections, severally or together, produce pyrexia, anæmia, and other effects of a general kind sometimes alarming in their severity. One of these is severe epistaxis, due probably to the impoverished state of the blood.

The complaint, as chiefly met with in Rustenburg, is confined to boys of from 6 to 15 years of age. At the latter period the hæmaturia generally disappears, and the other symptoms improve so greatly that the patient

regards himself as cured. But a careful examination of the urine will often reveal the presence of ova for very many years afterwards, although quite unsuspected by the patient. Subsequently there tend to form oxalic and uric acid calculi in the kidney and bladder, and, in the bladder and rectum, the new growths already referred to. Renal calculi are particularly common, giving rise to the usual symptoms of acute pain, nausea, etc., which their passage to the bladder commonly occasions. Other sequelæ, as pyo- and hydro-nephrosis and hepatic abscess, are less common but more serious. They are accompanied by the symptoms proper to these several lesions, and it is to them, and others of the same serious nature, that a fatal result, when it occurs, is due.

Although most of the cases one sees are in boys of the age stated, yet the disease is not infrequent, even in the hæmaturic stage, among men of all ages. Harley records a case in an old man of 76.[1] As previously mentioned, several instances have come under my notice where young adults, lately arrived in the district of Rustenburg, have contracted it. If it occurs among females there to any extent, it must do so without often causing hæmaturia, and I have not, as yet, met with such a case.

The condition of the urine in the *Bilharzia* disease calls for special notice, as upon it usually rests the clinical diagnosis of the complaint. The presence of blood is to the naked eye the most striking abnormality, the urine in some cases being quite opaque from the large quantity it contains. Most often the upper strata in the urine glass are clear, the blood sinking to the bottom, especially when, as so often happens, it has been passed in the form of clots at the end of micturition. On testing by boiling and the addition of nitric acid, albumen to an amount depending on the admixture of liquor sanguinis is precipitated. If the case be one in which the hæmaturia has only recently appeared, nothing else abnormal may be discovered by naked-eye examination, or chemical tests. By the aid of the microscope, however, there may be seen either lying free in the urine, or, more usually, entangled in the meshes of the fibrin of the blood (Plate VIII., Fig. 1), or embedded in stringy masses of mucus (*vide* Harley's Plate, Fig. 2, *loc. cit.*),[1] the characteristic ova of the *Bilharzia hæmatobia*, often in enormous numbers. If the case be a more advanced one, complicated by catarrhal inflammation of the mucous membrane of the urinary tract, other changes will be met with. The urine will generally be found to be very acid, its specific gravity rather high, the quantity of blood much less, perhaps not at all visible to the naked eye; on standing it will deposit a copious sediment of urinary crystals, often with shreds of tissue amongst them, and microscopically in addition to *Bilharzia* ova, which are specially numerous in these shreds (Plate IX., Fig. 13), there will be found, mingled with the blood and mucus, pus cells, uric acid, and oxalate of lime crystals, and large numbers of epithelial cells from all parts of the urinary

[1] Harley, quoted by Hilton Fagge, *op. cit.* vol. ii. p. 703.

tract. In old cases where there has been a long-standing cystitis or pyelitis, pus, and not blood, forms the principal abnormal constituent of the urine, which is then apt to become pale in colour, of lower specific gravity and less acid reaction. Shreds of mucous membrane, containing embedded ova in great numbers, are now still more frequently passed, sometimes when a case has apparently been cured, and blood is no longer present. The ova may, after a time, entirely disappear, and nothing may remain to show that the patient has been a subject of the disease, except the presence of uric acid in excess and oxalate of lime crystals, or the evidence of some complication which has persisted, such as pyelitis or cystitis, or of some sequela which has supervened, such as formation of renal or vesical calculi. Where the disease has been slight and of short duration, the urine may return in every respect to its normal condition.

Diagnosis.

The detection of the ova of the *Bilharzia* in the urine or fæces is the only certain indication, clinically, of the presence of the worm in the body. Usually there is no difficulty in finding the ova, as they are present in such immense numbers in the urine, particularly in cases where the latter contains a good deal of blood. In some cases there is more difficulty; a trace of albumen, or the presence of oxalate of lime crystals, or an excess of uric acid, may be all that leads one to suspect the presence of the parasite, and repeated examinations of the urine may have to be made before any ova are discovered.

With ordinary care there ought therefore to be little fear of confounding this disease with any other. Without a proper examination of the urine, it is apt to be overlooked, especially in those who, having contracted it in infected districts, consult medical men elsewhere, who are unacquainted with the appearance under the microscope of the ovum; and the mistake has even been made, by such, of confounding it with Bright's disease of the kidneys. A patient of mine, a young German, son of a missionary near Rustenburg, who went to Germany when suffering from *Bilharzia* in its earlier stages, was told by three different medical men there that he had Bright's disease, and was treated by them for that complaint.

Prognosis.

The ravages of the *Bilharzia* in Egypt have been compared to those of the more rapidly fatal trichina disease in Germany. In South Africa the bad effects seem to be much less severe, nevertheless they are of such gravity that the prognosis must always be guarded, the more so that up to the present little or nothing has been effected in the way of a radical cure of the disease by treatment. The immediate

danger to life is small, but the exhaustion caused by the constant loss of blood, the ever-recurring attacks of pain, or the continued discharge of pus, is in many cases so great that life must thereby be shortened. A complete cure may sometimes be established, but in most cases, though all symptoms may have disappeared, there will always remain the fear, too often realised, that subsequent trouble in the shape of urinary or other disorders may, perhaps ten or twenty years later, make their appearance. I am frequently consulted by adults of all ages in the Rustenburg district in reference to ailments where the history points clearly to *Bilharzia* as the original cause. The most common of these is renal calculus, produced as already mentioned by the deposition of uric acid or oxalate of lime upon a nucleus of *Bilharzia* eggs. One of these was passed by a man of 34 years of age who had a history of severe hæmaturia, lasting from his eighth to his twenty-fourth year, and who had suffered from renal pain since his eighteenth year. On examining the contents of the small cavity seen in its section, after heating them gently in a little dilute hydrochloric acid, I had little difficulty in discovering numerous fragments of the *Bilharzia* egg cases, one of which, from the end of a shell, still bore the characteristic projecting spine (Plate IX., Fig. 11 *a*). In this case no ova were discoverable in the urine; there was also no blood, but a good deal of pus was present.

Patients with *Bilharzia* are not looked upon by the life insurance offices as eligible for life insurance.

Treatment.

The indications for the treatment of the *Bilharzia* disease are the following:—(1) The removal of the cause; (2) The alleviation of symptoms; (3) The prevention of sequelæ.

1. Removal of the cause, implying as it does removal from the blood, of the adult worm, and removal from the organs and tissues, of its ova, will manifestly be difficult of achievement. In regard to the adult worm, this result could only be brought about by means of some agent capable of killing the animal in the blood, where absorption of it could ultimately take place. Nothing has, up to the present time, been found to have any such power, for the reason that the animal taking up its abode in the interior of the veins cannot be reached except through the blood, and it is thus impossible to act upon it efficiently by means of the ordinary anthelmintics. In spite of this apparently insurmountable difficulty, all these agents have been tried, and success has been claimed by various authorities for one or other of them. For my own part, I have never observed any result attending their use. Variations in the quantity of blood passed are noticed, as, for instance, after large doses of turpentine, by which the amount of blood may be diminished, but ova continue to pass much as before, and the disease does not appear to be shortened in its course or influenced in any very important respect.

Harley[1] recommends a mixture of oil of turpentine and male fern for bringing away the ova; but probably only in one way, namely, by prophylactic measures, can we at all limit the duration of the helminthiasis. By taking care that no fresh parasites find their way into the blood it is probable that a definite, although unascertained, limit is placed to its duration. It is scarcely necessary to do more than mention the attempts which have been made to attack the parasite directly by means of vesical injections. It is not credible, knowing what we do of the pathology, that any success should seriously be anticipated from such a mode of treatment, except what might accrue from the effects of the injections upon any secondary lesion in the urinary tract. And that their use is not free from danger is proved by the occurrence of acute cystitis in consequence of such attempts.[2]

2. With regard to the alleviation of symptoms, fortunately much more success can be looked for from treatment. The hæmaturia is the commonest and most serious of these symptoms, as well as that generally first noticed; although it is by no means the symptom for which the physician is most frequently called upon to give relief. Indeed, it is generally neglected until the exhaustion and anæmia produced by its long continuance has induced the patient to seek advice. The administration of iron, especially in the form of the perchloride, is of the greatest benefit, not so much because it diminishes the amount of blood passed (although it probably also acts in that direction), as because it enables the patient to bear the drain upon the system, and combats the tendency to anæmia. The addition of arsenic (*Liq. arsenicalis hydrochlor.*) to the perchloride, prescribed with a bitter infusion, such as quassia, I have found very efficacious for the latter purpose. Violent exercise or severe exertion of any kind, and particularly riding on horseback, must be forbidden, the quantity of blood in the urine being always increased thereby. Complete rest should be enjoined whenever the amount of blood is excessive.

The occurrence of pain is, in the earlier stages of the disease, closely connected with the hæmaturia, being principally due to passage of blood-clots through the ureters. The same remedies are therefore indicated, and, in addition, aromatic diuretics (as buchu), and demulcent and diluent drinks should be given; or in severe cases the exhibition of opiates may be required. In the later stages, where the pain arises from the passage of uric acid or oxalate of lime calculi, the usual antilithic remedies will be called for, hypodermic injections of morphia being employed for the more acute paroxysms.

Irritability of the bladder is relieved by injections, once or twice a week, of saturated boracic acid or weak carbolic acid solutions. Other symptoms, such as epistaxis, diarrhœa, and digestive disorders, frequently call for treatment appropriate to their nature. The practice of mas-

[1] Harley, "On the Endemic Hæmaturia of the Cape of Good Hope," *loc. cit.*

[2] Guillemard, quoted by Hilton Fagge, *loc. cit.*

turbation must be especially guarded against, as, doubtless from irritation of the genital organs, the habit is exceedingly common amongst the victims of *Bilharzia*.

Whenever practicable the patient should leave the infected district. Where this is not possible he must carefully avoid using, either for drinking or bathing purposes, any water that might be the means of conveying fresh parasites into the system. Attention must be paid to diet and other general hygienic measures, and exposure to cold or wet and any over exertion or violent exercise carefully avoided.

3. The prevention of complications and sequelæ will be best effected by carefully carrying out the foregoing treatment in every case from the commencement. The daily use of bicarbonate or citrate of potash, in weak solution, is especially to be recommended with the object of combating the tendency to stone. Soothing and astringent injections into the bladder may be employed for the same purpose.

In regard to the treatment of such complications and sequelæ, when once established, nothing further need be said, since it differs in no respect from what is necessary in those same complaints under ordinary circumstances. Surgical interference is sometimes, though rarely, required for the removal of calculi from the bladder or urethra, or of papillomata and other new growths from the bladder or rectum.

Prophylaxis.

The uncertainty surrounding the question as to how the *Bilharzia* gains access to the body, renders it a difficult matter to say precisely and positively by what means we can make sure of preventing the disease. But many observations warrant us in believing that the greatest if not the only danger lies in the use for bathing or drinking purposes of the water of certain streams. It has been noticed[1] in Cairo that while the natives who drink Nile water without any precaution are extremely liable to infection, Europeans, who mostly use well water, are very little affected. I have frequently had opportunities in Rustenburg of observing the same fact with regard to the use of the water there. Indeed, it would scarcely be exaggerating to say that it is only the children who neither drink of nor bathe in the streams of that neighbourhood who escape the infection. Too much care cannot, therefore, be taken to ensure that all water used for domestic purposes be first freed from the parasite, by boiling or by filtration. Rain water, and water from properly closed wells, might perhaps be used without this precaution, but it is safest always to adopt it. Bathing in the streams or stagnant pools must especially be avoided, since it is in this way that the disease is most easily contracted. Allen[2] of Pietermaritzburg, who holds, very strongly, the view that infection takes place during bathing,

[1] Sonsino, *op. cit.*

[2] Quoted by Taylor in his "Manual of the Practice of Medicine," p. 721.

even suggests that circumcision should be performed to prevent the parasite lodging beneath the prepuce and thence passing into the urethra, as he considers that it is in this way the animal is enabled to gain access to the body.

I have had no occasion to think that, as Griesinger suggested, the disease is ever contracted through the eating of salads or fruit.

Were all the precautions necessary to its prevention only known and strictly carried out, not only would much suffering and ill-health be spared to those communities affected by the *Bilharzia* disease, but there is a possibility that the parasite itself might ultimately disappear from amongst them, since, so far as is known, it can only reach its sexually mature condition in one other host than man, namely, the species of monkey already mentioned. But until the development of the parasite from its embryonic to its mature condition has been fully traced, the danger of infection from some unsuspected source must always remain. It is, therefore, a matter of great importance that every fact which may in any way help towards this end be observed and recorded, especially by those, who, like myself, have exceptional opportunities of studying the subject.

DESCRIPTION OF PLATES.

PLATE VIII.

FIG. 1.—Blood-clot containing embedded *Bilharzia* ova. × 90.

FIG. 2.—(*a*) Immature ova, showing granular embryo mass. × 200.
(*b*) ,, more advanced. × 200.

FIG. 3.—Various forms of ova. × 200.

FIG. 4.—Mature ovum, showing the various parts of the embryo and the envelopes. × 350.
(*a*) Outer envelope or shell.
(*b*) Spine.
(*c*) Inner envelope or vitelline membrane.
(*d*, d^1) Globules extruded from lateral apertures into space between the body of the embryo, and the vitelline membrane.
(*e*) Integument of body of embryo, ciliated.
(*f*) Oral papilla, showing oral aperture and projecting ends of stalks of pyriform bodies.
(*g*) Œsophagus.
(*h*) Stomach.
(*i*) Commencement of intestine.
(*k*, k^1) Anterior and posterior contractile organs.
(*l*) Caudal depression.
(*m*) Pyriform body (right).
(*n*) Stalk-like prolongation forwards of right pyriform body.

FIG. 5.—Ovum, showing granular matter extruded from lateral apertures into space surrounding body. (Granules showed Brunonian movements.) × 350.

FIG. 6.—(*a*) Dehiscence of ovum; embryo (*e*) escaping by lateral rupture of shell (*s*). Vitelline membrane left in shell. × 250.
(*b*) Appearance presented by a ruptured shell from which the embryo has escaped. Vitelline membrane (*m*) seen protruding. × 250.

PLATE IX.

FIG. 7.—Free embryo, showing markings of cilia.
(*a*) Anterior series of lateral apertures.
(*b*) Posterior ,, ,, × 320.

FIG. 8.—Peculiar forms assumed by embryos after escaping from their egg-shells. × 300.

FIG. 9.—Usual form assumed by vigorous free swimming embryo.

FIG. 10.—Embryo in the act of freeing itself from its attachments previous to rupture of shell. Highly magnified.

FIG. 11.—Specimen of ovum in which the branches of the intestine run backwards nearly to the caudal extremity of the embryo.

FIG. 11A.—Fragment of shell with spine attached found in the nucleus of a renal calculus. × 600.

FIG. 12.—Copy of drawing (from Sonsino) of shell with laterally placed spine.

FIG. 13.—Shred of tissue (from a case of *Bilharzia*, of sixteen years' standing, supposed by the patient to have been cured), showing embedded ova. × 100.

PLATE X.

FIG. 14.—Highly magnified view of mature ovum (dorsal aspect), showing more clearly the various parts.

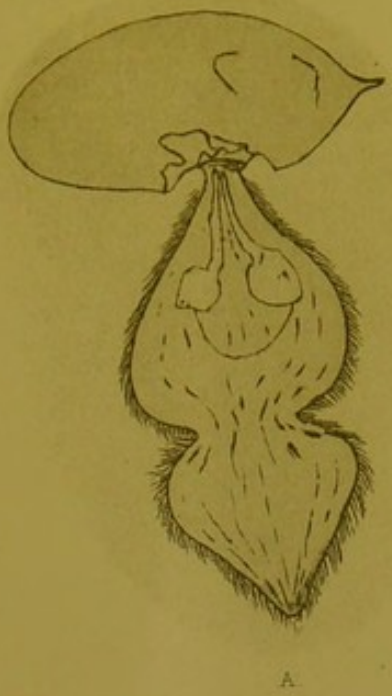
FIGS. 15, 16, and 17.—Mature ova. Highly magnified.

FIG. 15.—Dorsal aspect. Stalked masses uppermost.

FIG. 16.—Ventral aspect. Stomach uppermost.

FIG. 17.—Lateral aspect (from left).
(*a*) Alimentary canal.
(*b*) Stalked masses.
(*c*) Contractile organs and water-vascular system. Globules seen lying between cilia opposite lateral apertures, space outside body full of granules.

Fig 7



A

B.

Fig 8.

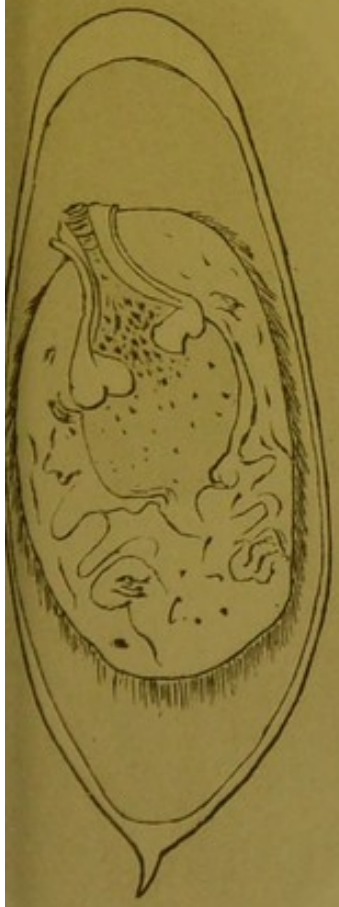


Fig 10

Fig 9

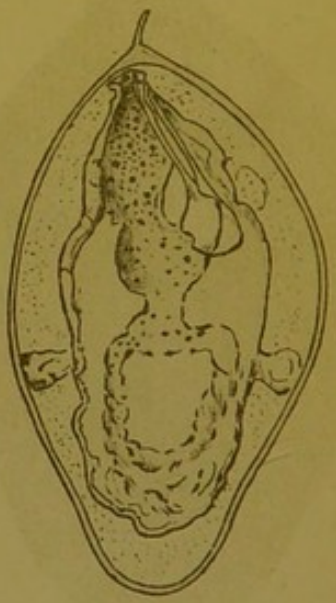


Fig 11.

Fig 13

Fig 11a

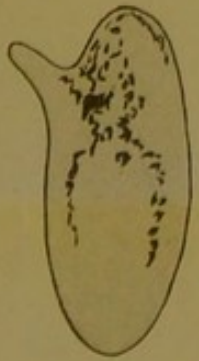


Fig 12

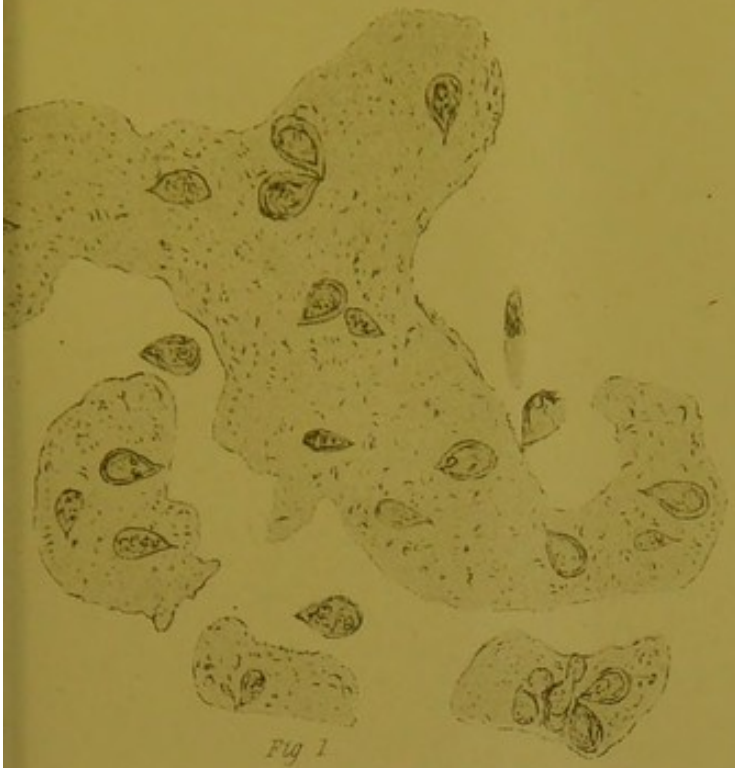


Fig 1

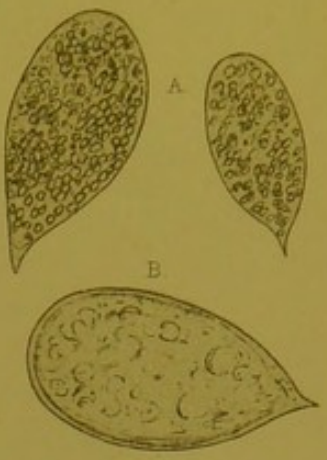


Fig 2

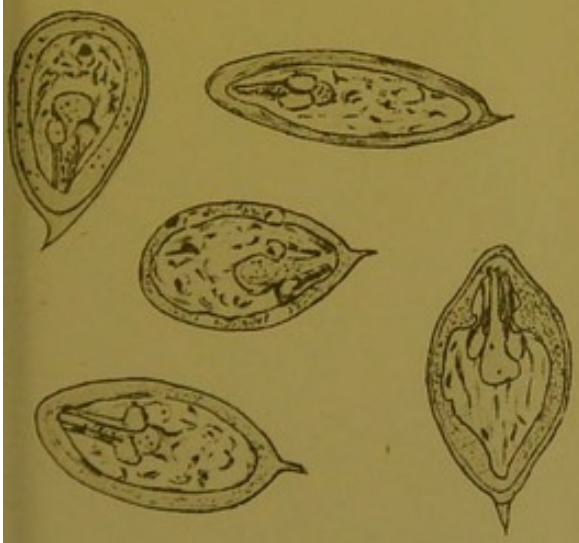


Fig 3

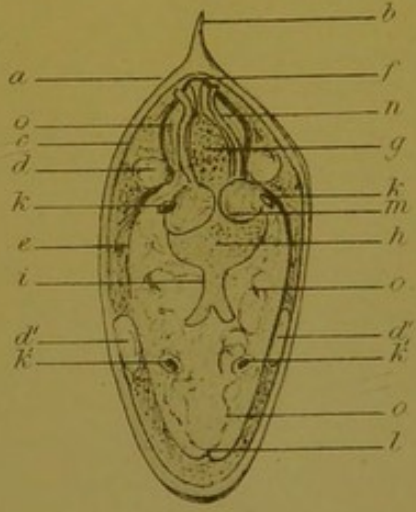


Fig 4

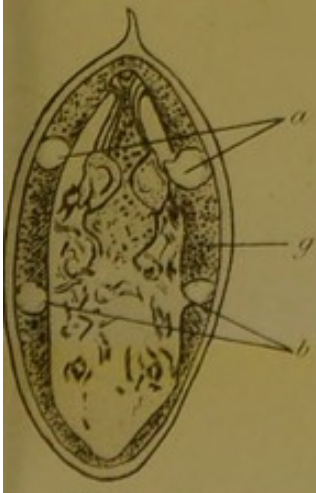


Fig 5

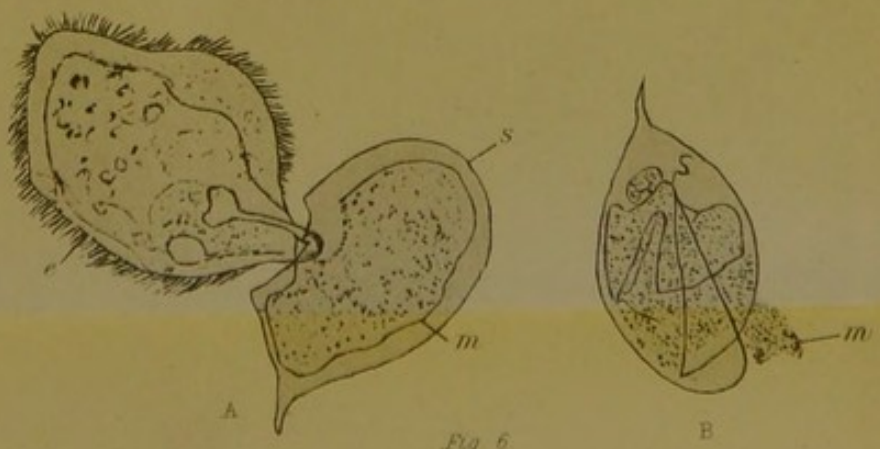


Fig 6

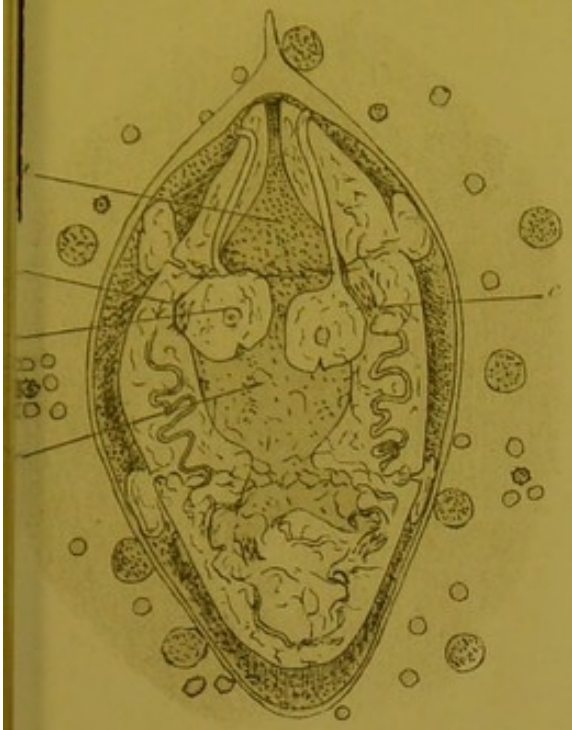


Fig. 15.

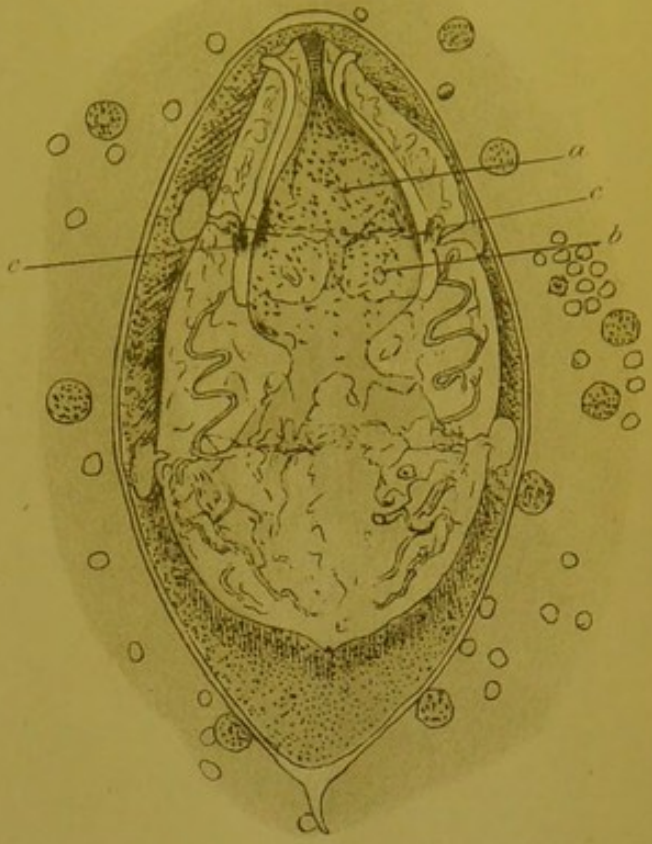


Fig. 16

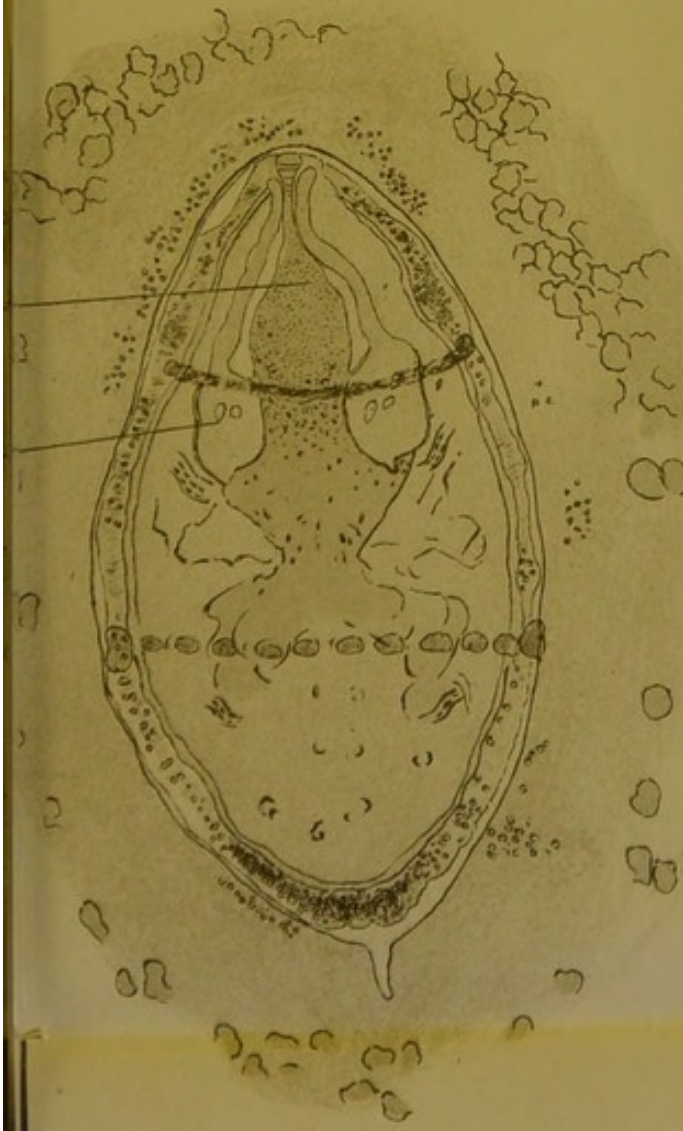


Fig. 14

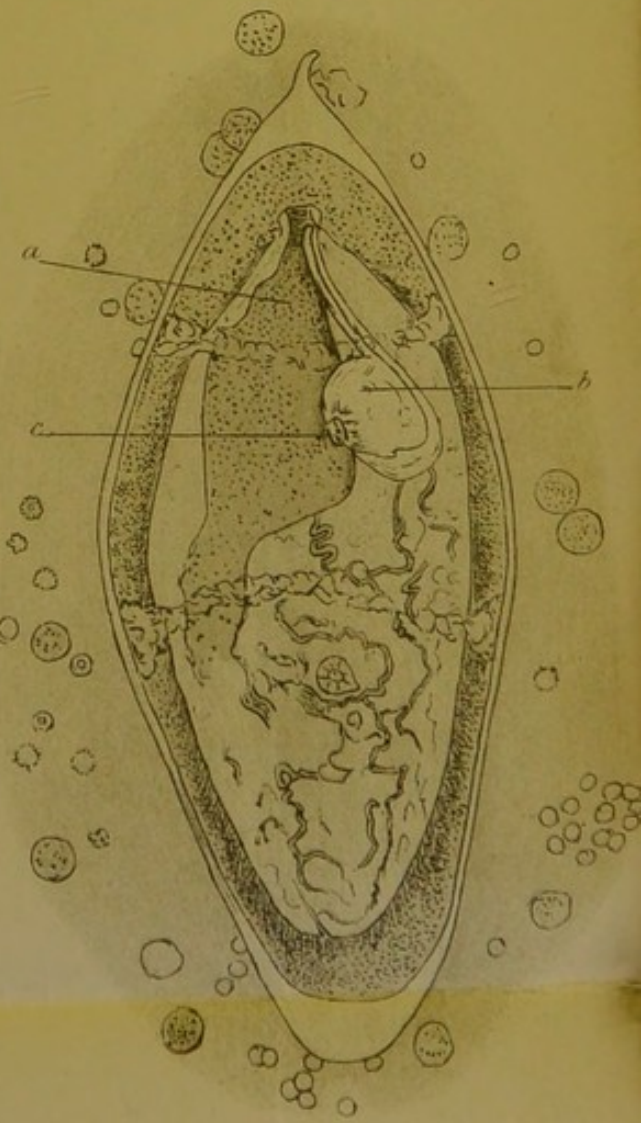


Fig. 17