Operators who cannot operate during ether anaesthesia, because of the increase in the respiratory movements, might with advantage pay a visit to the United States, where ether is used almost exclusively, and where nothing is heard of "abdominal excursions."

For cases of septic peritonitis, ether, especially if given by an expert, as in the above case, is almost ideal.

REFERENCE.

¹ *Lancet*, December 29th, 1906, p. 1767.

PRELIMINARY NOTE ON THE LIFE CYCLE OF A SPECIES OF HERPETOMONAS FOUND IN CULEX PIPIENS.

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It is well known many insects are infected with harmless flagellate organisms the majority of which are very imperfectly known, the adult forms having alone been described. A large number of these parasites belong to the genus *Herpetomonas*, and are characterized by the absence of an undulating membrane, the flagellum passing out directly from the anterior end. Excepting a short account of *Herpetomonas subulata* by Léger,¹ which I shall refer to later, the only description of the development of one of these parasites is that of *Herpetomonas muscae domesticae* by Prowazek,² who in addition to giving a detailed account of its structure, mentions three possible methods of infection and a complicated process of propagation.

In December, 1905, when feeding mosquitos (*Culex fatigans*) on cases of kala-azar, it was found that a small percentage of the females were infected with flagellates very similar to the cultural forms of the Leishman-Donovan body, and a little later Christophers saw similar parasites in the males of *Culex fatigans* and certain developmental stages in the larvae. As far back as 1898 Ross found these flagellates in the larvae, nymphs and adults of *Culex fatigans*, and since then Léger and others have found similar parasites in the intestinal tracts of many insects.

The similarity between the developmental forms of the Leishman-Donovan body in the bedbug (*Cimex rotundatus*) and these flagellates of insects has led to the careful investigation of the life-cycle of a species of *Herpetomonas* found in *Culex pipiens*. Having seen certain stages of these flagellates in the larvae and the mature parasites in the faeces of the adult mosquitos, I concluded that the larvae probably became infected by ingesting the flagellates passed into the water. The hind gut of a larva was dissected out, the anterior portion isolated, spread out on a slide with two fine needles, and stained deeply with Giemsa's stain. Lying apparently in the gut, and in many cases close up to the nuclei of the intestinal cells, there were a number of round and oval parasites (Fig. 1), measuring from 4μ to 8μ in length and from 3μ to 5μ in breadth; their protoplasm, stained deep blue, was granular, and contained a few vacuoles. The macronuclei, which were circular in shape, staining light pink, and containing a number of fine chromatic granules, were usually seen lying at one end, while the micronuclei, staining almost black, were rod-shaped, and situated at the periphery or the centre of the parasites. Many of these cells, which were much enlarged, were seen in all stages of simple longitudinal division (Figs. 3a, 4a, and 5a), and in some the macronuclei and micronuclei had divided a number of times and arranged themselves along the periphery, and on the protoplasm dividing from four to six parasites were produced (Figs. 3b, 4b, and 5b). All these changes were seen taking place while still attached to the wall of the hind gut; some of the parasites had already flagellated, and were lying in pairs (Fig. 8b) with flagella of varying length, and had undoubtedly resulted from the longitudinal division of the round and oval parasites. In the nymphs some of the free forms had increased considerably in size, their macronuclei and micronuclei dividing again and again, resulting in the formation of rosettes (Figs. 6a, 7, 8a, and 9). In the older nymphs the individuals had flagellated, and the rosettes were beginning to break up, and in the adult mosquitos

the parasites were seen as elongated spindles with oval macronuclei and rod-shaped micronuclei lying between them and the anterior ends, from which long wavy flagella protruded (Fig. 11).

From this short description it will be seen that this parasite has a stage in its development when it is very similar in form to the Leishman-Donovan body, and, further, that it multiplies by longitudinal division and multiple segmentation* as that parasite does in the human tissues. When free in the hind guts of the larvae and nymphs it further multiplies in a similar manner to the Leishman-Donovan body in the bedbug.

Though there are still some gaps in the life-cycle of the *Herpetomonas* of *Culex pipiens*, enough is already known to compare it shortly with *Herpetomonas muscae domesticae*. Prowazek regards the parasite of the house fly as a bipolar flagellate in which the body has become bent so that the two ends have fused, the two flagella remaining distinct. Excepting the forms showing longitudinal division, I have never seen a single parasite with two flagella; further, there is at present no evidence of the bipolarity of any flagellate. In addition to the motile forms, Prowazek describes gregarine-like parasites, and believes their appearance confirms Léger's view of the relationship of these flagellates to the gregarines. I have frequently noticed these so-called gregarine-like forms both in the development of this parasite and in that of the Leishman-Donovan body, and they appear to represent either parasites whose flagella have not yet developed or have not been sufficiently stained.

Prowazek does not mention any stage in the development of *Herpetomonas muscae domesticae* similar to that of my parasite in the hind gut of the mosquito larvae. He describes a process of copulation in the parasites of the house fly prior to which there is a marked reduction in the flagellate apparatus, and two similarly constituted forms are then seen lying side by side. The macronuclei and micronuclei of the two parasites then unite to form a single macronucleus and micronucleus, and later a permanent cyst is formed which is passed out in the faeces of the fly. Prowazek also mentions three methods of infection: (1) The indifferent individuals from the cysts may be again taken up by flies; (2) the sexually differentiated forms copulate, forming a permanent cyst, which is passed out in the faeces and may be ingested by other flies; (3) sexually differentiated forms penetrate into the ovaries, where they undergo autogamy and infect the next brood, but no description of the parasites in the eggs is given.

I have so far been unable to observe any sexual process in my parasite and the examination of ovaria and eggs has proved negative.

I have also been able to follow some of the stages in the life-cycle of a species of *Crithidia* found in a small Homoptera. In the mid gut of the young nymphs of this water-bug there were similar round and oval bodies (Fig. 12) apparently lying in the epithelial wall with circular macronuclei and rod-shaped micronuclei. Longitudinal division was also observed resulting in masses of round and oval forms attached to the epithelium, but there was no evidence of multiple segmentation. While still attached flagellation takes place, and these parasites are then seen undergoing equal and unequal longitudinal division resulting in forms of all sizes.

The adult parasite is a long, sickle-shaped organism (Fig. 13) with both ends attenuated, the anterior being prolonged as a rudimentary undulating membrane along which the flagellum is attached. This parasite is very similar to *Herpetomonas subulata* described by Léger from *Tabanus glaucopsis* and *Haematopota italica*, of which he recognizes two types:

1. *Formes monadiennes*, represented by the adult flagellate, which is a long attenuated parasite with a central macronucleus and a round or rod-shaped micronucleus situated near it; both ends of the flagellate are drawn out, the anterior being prolonged as a rudimentary undulating membrane to which the flagellum is attached.

2. *Formes grégariennes*, represented by oval or round parasites which are usually seen lying in masses attached to the epithelium. These forms undoubtedly represent the earlier stages in the development of the parasite, which are characterized by longitudinal division and development of the flagella.

* It is interesting to note that Schaudinn depicts very similar herpetomonad methods of multiplication in his figures of the spirilliform stages of *Leucocytozoon ziemanni* in *Culex pipiens*.

CYCLE OF THE DEVELOPMENT OF HERPETOMONAS OF "CULEX PIPIENS."

Fig. 1.—Small round and oval forms similar to the Leishman-Donovan body.

Fig. 2.—Similar form further enlarged.

Fig. 3a.—Division of the macronucleus and micronucleus preparatory to simple longitudinal division.

Fig. 3b.—Multiple division of the macronucleus and micronucleus prior to multiple segmentation.

Fig. 4a.—Simple longitudinal division into two oval bodies.

Fig. 4b.—Further stage of multiple segmentation.

Fig. 5a.—Two oval forms, the result of longitudinal division.

Fig. 5b.—Six oval and round parasites the result of multiple segmentation.

Fig. 6a.—Enlargement and division of the macronucleus and micronucleus preparatory to the formation of a rosette.

Fig. 6b.—Flagellation of a round parasite.

Fig. 7.—Further stage of a rosette, the micronuclei dividing more rapidly than the macronuclei.

Fig. 8a.—Large rosette: the macronuclei and micronuclei are arranging themselves along the periphery, and the protoplasm is beginning to divide.

Fig. 8b.—Longitudinal division of the round flagellate into two.

Fig. 9.—Small rosette of eight flagellates attached by their anterior ends.

Fig. 10a.—A small flagellate from a rosette. The micronucleus is still close up to the macronucleus.

Fig. 10b.—Elongated flagellate developed from a free round flagellate.

Fig. 11.—The adult flagellate, showing the central oval macronucleus, the rod-shaped micronucleus, and the long free flagellum.

The cycle omitted between Figs. 11 and 1 has not yet been fully worked out. All the parasites were drawn with a camera lucida, and are magnified about 900 diameters.

THE CRITHIDIA OF THE WATER-BUG.

Fig. 12.—Two oval forms similar to the Leishman-Donovan body attached to an epithelial cell.

Fig. 13.—The fully-developed flagellate. The micronucleus is situated close to the macronucleus, and the flagellum is attached to a rudimentary undulating membrane.

Drawn with a camera lucida, and magnified about 900 diameters.

The presence of an undulating membrane, the more central position of the micronucleus and the method of development of *Herpetomonas subulata* suggest that, like the parasite of the water-bug, it belongs to the genus Crithidia.

Léger¹ believes that some of these Crithidia and Herpetomonas found in blood-sucking insects represent stages in the development of haemoflagellates of vertebrates and considers Schaudinn's observations on *T. noctuae* in *Culex pipiens* confirm his opinion. Many parasitologists, however, now believe that Schaudinn was dealing with more than one parasite in *Culex pipiens*, namely, either *Leucocytozoon ziemanni* or *Halteridium danilewskyi*, together with the trypanosome of the owl and the Herpetomonas of *Culex pipiens*; and further, I have often seen many spirilla of large size with more than one chromatic dot in their protoplasm in the mid guts of *Culex pipiens* and *Culex fatigans*. There can be little doubt that the Crithidia of the water-bug is in no way connected with any blood parasite. I shall reserve for a later occasion a complete account of the life-histories of these two parasites.

CONCLUSIONS.

1. The Herpetomonas of *Culex pipiens* and the Crithidia of the water-bug have a stage in their life-cycles in which they are very similar in form to the Leishman-Donovan body, and, further, that the former multiplies in a similar manner to the human parasite. In order to study the early stages of these parasites it is necessary to examine the hind guts and mid guts of the larvae and nymphs of the insects.

2. These two parasites pass their complete cycles in their insect hosts, and have no connexion with any blood parasite.

3. The early stages of these parasites and their method of development, together with the constant anterior position of the blepharoplast and the absence of the fully-developed undulating membrane in the mature flagellates, all suggest that they are quite distinct from the Trypanosomata.

4. There is at present no evidence of a sexual cycle or of the infection being inherited.

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¹ Léger, Sur un nouveau Flagellé des Tabanides, *Comptes Rendus de la Soc. d. Biol.*, T. 57, N. 37. ² Prowazek, Die Entwicklung von Herpetomonas, einem mit dem Trypanosomen verwandten Flagellaten, *Arch. a. d. Kaiserl. Gesundheitsamt*, B. xx.

ON

THE DUTY OF RESTORING HEARING BY OPERATION IN CHRONIC AURAL SUPPURATION.

AN ADDRESS DELIVERED BEFORE THE WEST KENT MEDICO-CHIRURGICAL SOCIETY.

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AURAL appendicitis is the name by which chronic aural suppuration might be known, for disease of that mucous cul-de-sac the mastoid antrum or appendix of the ear is responsible, according to my investigations, for the perpetuation of the discharge. Like appendicitis in the abdomen, that in the ear is also a latent danger. In both situations it is a grave disease on account of its liability to infect neighbouring and vital parts. In the abdomen it may cause local abscess or fatal septic infection of the serous peritoneum (peritonitis); in the ear it may cause local or cerebral abscess, or fatal septic infection of the jugular vein or the serous pia mater (meningitis). Now no careful surgeon waits for abscess in abdominal appendicitis, nor in my opinion should he wait for it in the ear, for just as removal of the abdominal appendix will eradicate the danger there, so will timely elimination of the aural appendix usually restore the ear to function and to safety.

Before alluding to the investigations resulting in the proof of these opening words,¹ I will ask you to examine this patient, M. L. Her illness of five years ago has rendered her a person of great interest, for the restora-

tion of hearing which accompanied the repair of the drum of her ear encouraged the hope of ultimately discovering how this remarkable reparative power could be made generally available. She had suffered for many months from a foul aural discharge. This culminated in acute mastoiditis, and the disease having thus become critical, operative relief was urgently needed. The disease had already destroyed the posterior fourth of the drum membrane, and the operation I performed was adapted to the condition of the ear. The mastoid process being extensively diseased was all removed, and the antrum was opened as far forward as the attic of the tympanum. The posterior wall of the bony meatus and parts of the attic bridge and tympanic ring were also removed. The small bones and the remains of the drum membrane were retained and preserved from injury, and though the tympanum was full of granulations they were left untouched. She rapidly recovered, and now you can see there is no external disfigurement, and no internal sign to indicate that she had had an operation, nor that anything has been amiss with her ear. The extensive damage to the drum membrane has been repaired, and there is full restoration of hearing. Careful observation of her recovery encouraged other investigations, and thus little by little information was obtained, which, by the Institution last year of an appropriate operation, has led to the restoration of hearing in over a hundred persons. There can be no doubt that in time to come vast numbers will receive similar relief. This sudden change in treatment is due to the recognition of our ability to restore hearing by the new operation, and implies dissatisfaction with the old radical method which does not do so.²

In 1904 I endeavoured to render more satisfactory the method known as the radical or complete operation, which was the one in general use; but I found, among the other defects of that severe measure (which was founded on the assumption that it was necessary to clear out the drum as well as the mastoid antrum in order to effect a cure), that removal of the drum membrane, which is part of the proceeding, destroyed all chance of full restoration of hearing, and further, there was no certainty of saving the little that remained. Therefore, I returned to the study of the means by which Nature had assisted this patient, M. L., to make such a remarkable recovery. Observation of her ear after operation proved that the drum possessed great capacity for repair. Close attention was therefore given, during and after the performance of many operations, to the state of the tympanic walls, to the changes that appeared in the small bones removed from the ear, to the pathological conditions found in the mastoid antrum, and to the relation they might hold to those in the tympanum. Also to the conditions present in those patients in whom acute disease had caused destruction of the whole or a large part of the drum membrane and ossicles, and where no tympanic barrier existed to free drainage from the dangerous mastoid antrum. Observation of these and other matters resulted in the conclusion that, if the antrum could not recover its health when there was no tympanic obstruction to its drainage, then the operation known as ossiculectomy (that is, removal of drum membrane and small bones), with the object of influencing the disease in that cavity, was futile, in spite of the sacrifice of the vibrating apparatus and consequent certainty of defective hearing. Treatment of the tympanum through the meatus, by dealing also with the effect and not with the cause of this disease, was usually found equally ineffective, and in early cases even worse. The delays such proceedings must entail were found to give time for the affection to advance beyond the point at which restoration of hearing might be brought about by operation. During operations it was also found that slight disease may exist in the mastoid antrum, yet not be identified, because of the obscuring presence of blood, and that all haemorrhage must be prevented if trustworthy observations were to be made.

Now, these studies have shown, as clearly as such things can be proved, that the mastoid antrum is affected in every case of chronic aural suppuration—that is the plain teaching of careful observation of upwards of 500 operations. It was only by the performance of operations that this most important information was forthcoming, and even then it could not be demonstrated except when absolute freedom from haemorrhage permitted of full and critical view.