ON THE OCCURRENCE OF STRONGYLOIDES INTES-
TINALIS IN THE UNITED STATES.

BY WILLIAM SYDNEY THAYER, M. D.,
Associate Professor of Medicine in the Johns Hopkins University.

PLATE IX.

HISTORICAL.

In 1876 Normand (1876),* a French naval surgeon, discovered a
small nematode in the dejecta of patients who had contracted severe
diarrhoea in Cochin China. This parasite, present in enormous num-
bers, was afterwards studied more carefully by Bavay (1876), who
described it as Anguillula stercoralis. The worm, according to Bavay,
differs but little from the terrestrial anguillula, Rhabditis terricola Du-
jardin, genus Leptodera of Schneider. The parasites were usually
met with, in the stools, as larvae, measuring about 0.33 x 0.023 mm. in
size. When the stools were kept in uncovered vessels at a sufficiently
warm temperature, these larvae underwent development, reaching full
growth and sexual differentiation in about five days. The length of
the full grown female was about 1 mm.; its breadth about 0.04. The
body was cylindrical, slightly diminishing in size anteriorly and taper-
ing to a sharp point posteriorly. When the worm retracted forcibly,
slight transverse furrows were to be seen. The mouth as described
by Bavay, possessed three distinct lips, and was continuous with the
triangular oesophagus, which, after a stricture, dilated again into a
second ovoid enlargement. The intestine, which followed, was fairly
visible, and ended in a little protrusion on one side of the body near
the base of the tail. The intestine was pushed slightly aside by the
uterus. A little below the middle of the body, and on the ventral
side, opened the vulva, leading to the uterus, which extended from the
intestinal ventricle to a point near the anus. Here the eggs were
massed in varying number. In some instances the young had actually
broken the shell of the eggs, and were free in the uterus, though more
often the eggs, on deposition, contained well formed, motile embryos.

* References to authors are arranged alphabetically at the end of this article.
Strongyloides Intestinalis in the United States

The male was about one-fifth smaller than the female. The peri-intestinal cells were more clearly outlined, and were accompanied by another long gland, which seemed to consist of small rounded globules. This organ, doubtless the testicle, ended at the base of the tail in two small, horn-like spicules with tapering extremities curved inward; these spicules contained canals. They were of equal length, and were situated symmetrically on a transverse plane. The tail, which was coiled also in the same direction as the spicules, was twice as short as that of the female. The authors further described copulation, the laying of eggs and the development of larvae. Neither Normand nor Bavay were able to cultivate the adult animal from the second generation.

In the following year Normand (1877) discovered a second nematode, present, in association with these parasites, in the small intestine of a patient dying from Cochin China diarrhoea. Bavay (1877) 1, 2, who afterwards found this parasite in a number of autopsies upon similar cases, described it as a distinct species, which he termed Anguillula intestinalis. It was met with only in the female form, the length of which was 2.20 mm. the average breadth 0.03. The body, a little tapering anteriorly, terminated, rather suddenly, posteriorly in a conical tail, the extremity of which was appreciably rounded, and even a trifle dilated. With a sufficient magnification, the surface showed a very delicate transverse striation. The mouth, without horny armature, showed three small lips. It opened into an oesophagus, practically cylindrical, which occupied about one-fourth of the length of the animal, and showed neither swellings nor striations. It was followed by an intestine, with which one might readily confound it, without a marked change of color. This intestine extended nearly to the posterior extremity of the body, but it almost ceased to be visible in the middle part, which was occupied by a very large, elongated ovary. The vulva was situated in the posterior third of the animal, and, in its neighborhood, the uterus contained usually five or six rather elongated eggs. The anus, a transverse slit, was situated toward the base of the tail. The eggs and the viscera were of a yellowish green color, rather opaque and apparently finely granular. All individuals observed were oviparous females. Bavay questioned whether the absence of males was due to their prompt disappearance after coupling, or whether, as Schneider has shown to be the case in certain nematodes, the worm is unisexual when free, and hermaphroditic with a female habitus when parasitic.

These worms were abundant in the duodenum, rarer in the jejunum;
they were not found as far down as the ileum. Once, they were found in considerable numbers with embryos of A. stercoralis in fluid coming from the stomach. In intestines where the worm was found, it was not uncommon to find also series of eggs, often joined together, sometimes isolated. In some of these the embryo, in the process of formation, showed a definite row of dorsal cells; in others its development was more advanced.

These parasites were hardly ever found in the stools. Bavay (1877) found the worm in six cases, and in five of these only at autopsy. The development of the eggs was not observed, but Bavay (1877) makes the following statement:

"In three diarrhoeic stools which we had preserved to follow the development of the Anguillula stercoralis, we found, at the end of several days, that they contained larvae different from the first. These were, as a matter of fact, longer, with a cylindrical oesophagus descending down to about the middle of the body, and a tail, which, instead of terminating in a fine point, was, on the contrary, apparently truncated at its extremity. Although the culture of these larvae could not be carried far enough to establish in an irrefutable fashion their identity with the Anguillula intestinalis, yet we had no doubt with regard to this point. Indeed, two of the patients who presented this form in their stools, have succumbed since then, and the autopsy has shown us the complete form. The third case still lives."

Both Normand and Bavay were inclined to regard the parasites, especially Anguillula stercoralis, as important etiological factors in Cochinchina diarrhoea.

These observations were partly confirmed in 1877 and 1878 by Laveran (1877), Libermann (1877), Roux (1877) and Chastang (1878) in patients from China, and by Chauvin (1878) in a case originating in Martinique. Their observations related almost entirely to the discovery of rhabditiform embryos in the stools. Chauvin, however, states that he was able, in cultures, to follow the deposition of the eggs by the adult female, and that he noted the presence, together with the embryos of the new generation, of a longer, thinner and more motile worm, "probably that which has been mentioned by Normand."

In 1878 Grassi (1878, 1879) and Parona (1879) discovered A. intestinalis at a number of autopsies in Pavia, and published a careful description of the mother worm, of the eggs and of the embryos developing from them.

The mother worm was found throughout the upper gastro-intestinal tract, especially in the lower part of the duodenum and the upper
part of the jejunum, though they were occasionally met with throughout the jejunum and in the upper part of the ileum. They have been found in the stomach. In some cases the intestinal mucosa appeared to be perfectly healthy. The eggs, deposited in the intestinal tract, hatched almost immediately after being laid. They were found, as a rule, in close proximity to the mother worm. It was extremely rare to find the eggs in the stools. The embryos in the feces, which were almost exactly similar to those described by Normand and Bavay as *A. stercoralis*, were identical with those found in the intestine. In cultures kept at room temperature in July, the feces being moistened with a little water, these worms were found to grow gradually, until, after four or five days, sometimes longer, they measured about 0.6, while the breadth diminished to about 0.015. The two bulbous enlargements disappeared from the oesophagus, which occupied more than a third of the entire length of the animal, and was bordered by granulations. The genital rudiment had disappeared. After ten or twelve days, many of the worms were 0.75 long, but the longest were only about 0.029 or 0.03 in width; the oesophagus occupied one-half the length of the animal.

It was pointed out that, at this stage, the embryos were similar to those forms observed by Bavay and Chauvin in feces which had been kept for some time; forms which Bavay (1872) had believed to be larvae of *A. intestinalis*. They failed to observe in their cultures, at autopsy, or in the stools, a single sexually differentiated *A. stercoralis*.

Grassi (1879) placed the worm in a special genus, closely allied to *Strongylus*, which he termed *Strongyloides*, and later (1879) he suggests the specific term *Strongyloides intestinalis*. This classification has been accepted by the best authorities.

At the same time Perroneito (1880-14, 1881, 1882, 1883) called attention to the presence of *Anchylostoma duodenale* and also *Anguillula intestinalis* and *A. stercoralis* in the intestinal tract of workers in the St. Gothard tunnel. He (1881, 1882) succeeding in cultivating, from rhabditiform embryos found in the fresh feces, adult *Anguillula stercoralis*, which he termed *Pseudo-rhabditis stercoralis* (Bavay). The original rhabditiform embryos were, from his descriptions, essentially similar to those described by Normand, Bavay, Grassi and Parona. He described and pictured with accuracy the development of the adult male and female forms from the rhabditiform embryos in the stools, their copulation, the laying of eggs, the hatching of these, and the gradual transition of the young embryos of the second generation into filariform larvae,
very closely similar to those described by Grassi and Parona as the final stage of the metamorphosis of the rhabditiform embryos, the descent of which from Anguillula intestinalis they had traced.

Perroncito also described A. intestinalis, but contrary to the observations of Grassi and Parona, he asserted that the eggs of this worm appeared in great numbers in the stools, and were, at some stages, indistinguishable from those of Anchylostoma duodenale. In cultures, the larvae developing from these eggs were closely similar to those of Anchylostoma, the differences described being extremely slight.

The differences between the larvae of Anguillula intestinalis and A. stercoralis, Perroncito believed to be slight but yet characteristic. He maintained, however, that the larvae of A. intestinalis and Anchylostoma were never found in recent feces. In his own words: “This is sufficient of itself to establish the diagnosis” (1880).

These observations were followed by a rather spirited controversy, Grassi (1882, 1883) maintaining, and proving beyond a doubt, that Perroncito had fallen into error in assuming that the eggs of A. intestinalis were passed in any number in the feces. He showed, clearly, that Perroncito had been dealing purely with Anchylostoma eggs. He insisted that the rhabditiform embryos found in the dejecta were direct descendants of the strongyloid so-called Anguillula intestinalis, and, in view of the apparently clear evidence that these embryos often develop, in cultures in the free state, into sexually differentiated adult parasites, so-called Anguillula stercoralis, he advanced, in 1882, the hypothesis, based upon a number of observations, that Anguillula intestinalis was a dimorphobiotic parasite like Ascaris nigrovenosa; that the mother worm in the intestine was parthenogenetic or hermaphroditic; that the rhabditiform embryos developing from the eggs of these and escaping in the dejecta, developed into a sexually differentiated generation outside of the body; that the descendants of this sex-ripe generation were capable, after ingestion, of developing again, into the parthenogenetic or hermaphroditic parasitic mother worm.

In the same year there occurred, in the clinic of Gerhardt at Würzburg, a case which was carefully studied by Seifert (1883), Grassi, and Leuckart (1883), which was destined to shed much light upon this disputed question. Seifert sent specimens of the dejecta to Leuckart in Leipzig. These contained great numbers of typical rhabditiform embryos, unquestionably similar to those described by Normand, Bavay, Perroncito on the one hand, and by Grassi and Parona on the other. In cultures, these developed into sexually differentiated Anguillula stercoralis. The new embryos developing from the eggs of these under-
Strongyloides intestinalis in the United States

went the course of development described by Normand, Bavay and Perroncito, changing, eventually, into characteristic filariform larvae. Leuckart was convinced that these filariform larvae must pass over into a suitable host to return to complete development and sexual maturity, and from analogy with what he had previously observed in Ascaris nigrovenosa, he agreed with Grassi in assuming that these various forms were but different phases in the cycle of a single heterogenic parasite. "The structure of the filariform larva is such that they cannot possibly develop again into the rhabditis form. There must be another worm which develops from them, a variety which, in the shape of its body and the structure of the oesophagus resembles these." And Anguillula intestinalis possesses these characters. Owing to the entire absence of males he believed, as did Grassi, that the parasitic mother worm, of female habitus, was hermaphroditic or parthenogenetic. While he expressed no positive opinion, he was inclined to suspect that, as Schneider had shown to be the case in the analogous stage of Ascaris nigrovenosa, the so-called Anguillula intestinalis was hermaphroditic.

More recently, however, Rovelli (1888), who has investigated this question, has come to the conclusion that the worm is parthenogenetic.

Leuckart was strengthened in his views concerning the life history of the parasites by the fact that Grassi and Parona (1879) had demonstrated the origin of the rhabditiform embryos found in the dejecta from A. intestinalis, while both Bavay and Grassi (also Chauvin (1878)) had described filariform larvae in old cultures. He suggested for the parasite the name Rhabdonema strongylodes, and in conclusion says: "The Rhabditis stercoralis itself is to be erased from the list of essential parasites; it represents, like the Rhabditis ascaridis nigrovenosa, despite its sexual differentiation, an intermediate generation, developing externally, which forms a link in the chain of development of the Anguillula intestinalis."

At the suggestion of Grassi, who also observed this case, the patient was given on several occasions large doses of male fern, santonin and thymol. On one occasion, after an anthelmintic followed by a purge, two examples of the mother worm were recognized by Grassi (Seifert, 1883) in the faeces; both, however, were dead and had undergone considerable post-mortem change. On another occasion, after administration of apomorphia, a considerably degenerated A. intestinalis was found in the vomitus. No examples of sexually differentiated adult A. stercoralis were ever observed in the fresh stools.

In the same year Grassi (1883) emphasized the interesting fact that filariform larvae, identical with those into which the primarily rhabditi-
form embryos of the free living generation develop, may arise by direct transformation from the rhabditiform embryos of the parasitic mother worm, namely, the embryos found ordinarily in the dejecta. This direct transformation had been clearly described by Grassi and Parona (1879) four years before, and in the experience of the former, represents the ordinary method of development.

In support of these observations showing that the rhabditiform embryos of the parasitic mother worm may, under some circumstances, change directly into the filariform larvae, without the interposition of the sexually differentiated free living generation, Grassi (1883) notes the fact that exacerbations of the infection in patients who have been living in regions where fresh infection by the mouth is out of the question, are not uncommon. He also points out that it is not infrequent to find, in the cadavers of individuals who have remained in hospitals for several months, small and rather immature examples of *A. intestinalis*. Such a parasite was passed by the Würzburg patient. There is no evidence that the sex-ripe intermediate generation ever develops in the intestinal tract during life. Such forms are never found at autopsy. The presence, then, of immature forms of *A. intestinalis* at autopsy, and the increase in the number of embryos in the stools during life, must depend upon a direct transformation of the rhabditiform embryos into the mother worm without the interpolation of the sexually differentiated generation.

In 1884, Golgi and Monti (1884, 1885) made a careful study of this question in cases observed in Pavia. They confirmed in toto the observations of Grassi and Parona, and agreed with these observers in pointing out Perroncito’s error in assuming that the sexually differentiated, free living generation is a separate parasite. They followed in cultures the direct transformation of the rhabditiform embryos of the parasitic mother worm into the filariform larvae, as well as the indirect change through the free living, sexually differentiated generation. They agreed with Grassi in believing the former cycle to be the commoner.

In the meantime a number of other observers had described cases in which this worm was present: Breton (1879) in China; Sahli (1882) and Bozzolo and Pagliani (1880) in cases from the St. Gothard Tunnel, Ribeiro da Luz (1880) and Lutz (1885) in Brazil; Radetski (1886) in Russia; while Grassi (1878), Grassi and Calandruccio (1884), Grassi and Segrè (1887), Lutz (1885), and others described similar parasites in other animals. Since then Calandruccio (1889) and Barbagallo (1897) have found the parasite in Sicily; Sonsino (1889, 1891), Riva (1891) and de Silvestri (1895) in Italy; Ilberg (1892) in a case from the
Dutch Indies; Sonsino (1896) in Egypt; while Leichtenstern (1898, 1899) and Wilms (1897) have described a number of cases occurring especially in brickworkers along the Rhine, and Poppenheim (1899), a sporadic case in East Prussia. Pérez Valdés (1897) has observed the parasite in Spain, and Strong (1901) in the Philippine Islands.

The most important work of recent years has been done in the clinic of Leichtenstern. As a result of fourteen years' study of fourteen cases, this observer comes to the following conclusions (1898):

"(1) The direct metamorphosis of the Anguillula embryos into the filariform is the rule. In some of my patients with Anguillula, this method of development was observed exclusively for weeks and months, however one might vary the conditions under which the cultures were made.

"(2) The development of the sex-ripe intermediate generation, Rhabditis stercoralis, takes place commonly, but by far not so constantly and regularly as the direct metamorphosis.

"(3) In those cases again, which, in my experience, are unusual, where the development of the sex-ripe intermediate generation predominated continually or for transient periods, I have never failed to observe the direct metamorphosis as well.

"It is then a matter of purely facultative, by no means exclusive or obligatory heterogenicity."

As to the reason why, in one instance, the direct method of transformation should prevail, and in another the indirect, there has been much question. Wilm~ (1897), in Leichtenstern's laboratory, has proved definitely that it is not due to the existence of two distinct varieties of worm. This observer administered to human beings filariform larvae which had developed by the method of direct transformation from rhabditiform embryos of the parasitic mother worm. After seventeen days, rhabditiform embryos began to appear in the patient's stools. In culture experiments these characteristic rhabditiform embryos began to appear in the patient's stools. In culture experiments these characteristic rhabditiform embryos underwent, in part, a direct metamorphosis into new filariform larvae, but in part, developed into the sexually differentiated, free living generation, the so-called Rhabditis stercoralis, from the eggs of which, in turn, there arose rhabditiform embryos changing rapidly into filariform larvae.

Experiments with culture media, variations in the temperature, moisture, etc., to which the cultures are exposed, have failed to reveal any definite law as to the reason for the prevalence of one or another of these methods of development. Leichtenstern (1899), in his last article, has pointed out the fact that the sex-ripe intermediate genera-
tion is apparently commonest in cases which have been but recently imported from the tropics, while the direct metamorphosis is the rule among those instances originating in Italy, Belgium, Germany and Holland. It is, however, probable that all these worms were ultimately of tropical origin. So that one may be led to believe that the parasite, after entering into temperate regions, has adapted itself to the less favorable climatic outward conditions, in that in temperature zones, it tends to follow the direct method of transformation into the filariform larvae, a method which is simpler, more rapid and less dependent upon outward influences. And yet, despite this, in any given case there may, for a certain time, occur a change, as a result of which the development of the sexually differentiated intermediate generation prevails. The cause of such variations in the type of the cycle of development is quite obscure.

The only observer of recent years who has failed to recognize the heterogeneity of the parasite is Teissier (1895), who in 1895 reported a remarkable instance in which the stools contained worms which he believed to be identical with the rhabditiform embryos above described. In cultures they developed into sexually differentiated free living parasites closely similar to those described by Bavay, Perroncito, Grassi and others. In the circulating blood, however, there were also found numerous small larvae which he believed to be the earliest stages of these embryos. Contrary to the experience of almost all other observers, Teissier found adult, sexually differentiated forms, not only in cultures, but also in the fresh dejecta, and concludes that *Anguillula stercoralis* is a separate and distinct parasite.

There are, however, certain points in which his observations vary materially from those of others. In the embryos found in the blood, and the smallest forms observed in the faeces, which were from 220 μ in length, by 10-12 μ in breadth, no internal structure could be made out. All recent observers, however, have noted that excepting perhaps, in the very earliest stages, the embryos developing from the eggs of both parasitic and free-living generations, show, already, the characteristic double oesophageal enlargement. Teissier's description of the adult parasite also varies from those given by Normand, Bavay, Grassi, Perroncito and others, in that he was able to distinguish but one spicule in the male, instead of two, as noted by all other authors. The character of the young larva, the presence of adult forms in the fresh dejecta, the slight differences in the structure of the male parasite, might give rise to the suspicion that Teissier may have been dealing with a different species of a closely allied parasite.
In a later article Teissier describes remarkable results obtained by inoculating these parasites into frogs—results which, if confirmed, would support this idea. After inoculation he believed that the worms developed in the intestinal tract and lungs of the frog, into giant forms. It is not impossible that these giant forms may have been *Ascaris nigrovenosa* [= *Rhabdonema nigrovenosum*].

It should be remembered, however, that Teissier is not the only observer who has recognized what he believed to be adult forms of *Anguillula stercoralis* in the fresh dejecta. Normand (1877) stated that he had met with all known forms of the worm at autopsy. In 1878 he asserted that "nothing is rarer than to see *Anguillula stercoralis* in a state of complete development in dejecta of recent origin"—a statement which would justify the inference that he had seen such forms. In this latter article he also expresses his positive opinion that the adult forms do develop in the gastro-intestinal tract.

In consideration of the fact that these views are at variance with those of most other observers, and of the somewhat indefinite character of Normand's statements, it has been assumed (Leuckart, 1883) that the sexually differentiated *A. stercoralis* may develop in the intestine, but only after death when the conditions are essentially the same as in cultures outside of the body, a theory which would account for one of Normand's statements. It must be acknowledged, however, that this does not cover his apparent assertion that he had met with adult forms in fresh dejecta.

In view of the statements of these two observers, it would, perhaps, at the present time, be unwise to deny the possibility that, in rare instances, the sexually differentiated intermediate generation may develop within the human host.

**CLASSIFICATION.**

The following classification has been generally adopted:

- **Family:** *Angiostomidae*.
- **Genus:** *Strongyloides* Grassi, 1879.
- **Syn.:** *Pseudo-rhabditis* Perroncito, 1881.
  *Rhabdonema* Leuckart, 1882, pro parte.
- **Species:** *Strongyloides intestinalis* (Bavay, 1877).
- **Syn.:** *Anguillula stercoralis* (Bavay, 1877).
  *Rhabditis stercoralis* (Bavay, 1877).
  *A. intestinalis* (Bavay, 1877).
  *Leptodera stercoralis* (Bavay, 1877) Cobbold, 1879.
  *Leptodera intestinalis* (Bavay, 1877) Cobbold, 1879.
William Sydney Thayer

*Strongyloides intestinalis* (Bavay, 1877) Grassi, 1879.
*Pseudo-rhabditis stercoralis* (Bavay, 1877) Perroncito, 1881.
*Rhabdonema strongyloides* Leuckart, 1883.
*Rhabdonema intestinale* (Bavay, 1877) R. Blanchard, 1885.

It may perhaps be well to emphasize one point in connection with the synonymy. Most of the recent text-books—Railliet (1895), Moniez (1896), Braun (1895), Weichselbaum (1898)—in their synonymy, refer to the special term *Strongyloides intestinalis* as having been introduced by Grassi in 1883. I have searched the literature with considerable care, but have been unable to find any reference to the worm under this name in Grassi's publications of that year. The name, however, was first used by Grassi four years before. In an article in the *Rendic. r. Ist. lomb.*, Milano, 1879, xii, ser. 2, p. 228, he proposes the generic name *Strongyloides*, and in a review of his own article, in *La med. contemp.*, Milano, 1879, iii, 495, he says: “He concludes by referring *Anguillula* to a new genus, *Strongyloides*, which” (*Anguillula*) “should therefore be called *Strongyloides intestinalis*.” I have been unable to find any reference to this name in later publications by Grassi. In his articles appearing in 1883, he apparently accepted the classification of Leuckart—*Rhabdonema strongyloides*.

**PATHOLOGICAL SIGNIFICANCE.**

The fact that the worms were so frequently present in the severe diarrhoeas of Cochin China led Normand (1876, 1877, 1878) to assume that they played an important part in the aetiology of the disease. At that time, of course, the so-called *Anguillula intestinalis* and *Anguillula stercoralis* were regarded as distinct species. Normand (1877) recognized the fact that the parasites may exist in the intestinal tract for considerable periods of time without producing any serious symptoms. Man may harbor the worm for years with little or no inconvenience; there may be noted, perhaps, only a slight softness of the dejecta, or occasional transient attacks of diarrhoea. Anything, however, which tends to diminish the resistance may offer to the worms the opportunity to produce those intestinal changes which result in the clinical picture of Cochin China diarrhoea. This view was upheld by Laveran (1877 1, 2), Davaine (1877), Doumon (1879), Roux (1877) and Ribeiro da Luz (1880). Libermann (1877 1, 2), however, was very reserved in his views as to the part played by the worm.

On the other hand, Chastang (1878), Breton (1879), Lutz (1885) and Calmette (1893) were inclined to doubt its pathogenicity. Grassi (1879 1) found the parasites in the stools of many healthy individuals.
and while confessing that it was hard to believe that their action was not in some way harmful, yet he had never been able to make out any special symptoms attributable to the infection. He did not believe that the parasite was the cause of Cochin China diarrhoea. Later (1883) he asserts positively that "Anguillulae are innocent commensals of man."

Golgi and Monti (1884, 1885), however, found distinct anatomical changes which they believed to be dependent upon the irritative influence of the worms, evidences such as could leave no doubt that, in some cases at least, the parasites must have a pathological significance, while Sonsino (1891) in a study of two fatal cases found evidence that the embryos may actually penetrate into the mucosa. He, as well as Golgi and Monti, frequently found worms occupying the lumina of Lieberkühn's ducts, while later, in the same cases, Venturi (Sonsino (1891)) discovered eggs and embryos in the depths of the villi and mucosa. Sonsino is strongly of the opinion that the worm may cause serious and even fatal changes. Riva (1891) likewise, from the study of a fatal case, is convinced of the pathogenic importance of the parasite, which he is inclined to consider the essential causal agent of the disease. The action of the worms is, he believes, wholly mechanical. More recently, Askanazy (1900) also has demonstrated that the worms may actually penetrate into the submucosa.

Teissier (1895), indeed, has reported a remarkable instance in which small filariform larvae were found in the circulating blood, worms corresponding closely to the larvae of a parasite present in the stools, and identified by him as Anguillula stercoralis. As has been mentioned, however, there were peculiarities about the ease observed by Teissier which are sufficient to give rise to some doubt as to the identity of the larvae present in the blood.

Leichtenstern (1888), who has observed the constant presence, through years, of great numbers of the rhabditiform embryos in the stools of individuals in a relatively normal condition, while recognizing the fact that the presence of such enormous numbers of parasites may have a marked effect in increasing the severity of a diarrhoea when present, yet feels convinced that such a diarrhoea must owe its origin to some other primary cause, a view similar to that previously expressed by Calmette (1893).

Perroncito's (1880) theory that the parasite played an equal part with Uncinaria duodenalis in the production of the severe anemias observed in miners and tunnel workers, has long since been disproven. The removal of Uncinaria by proper treatment is sufficient to dispel
all symptoms of miners' disease, despite the fact that great numbers
of the rhabditiform embryos of Strongyloides intestinalis frequently
persist in the dejecta for long periods of time after the disappearance
of all evidence of the sister worms.

The weight of evidence appears to be in favor of the view that,
while the parasites may exist in the intestine for long periods of time
without ill effects, they are by no means, as Grassi says, "innocent
commensals of man." It would seem probable that this parasite alone
may be the primary agent in many cases of chronic diarrhoea.

The deleterious influence of the worm is generally supposed to be
purely mechanical [Golgi and Monti (1884, 1885), Sonsino (1891),
Riva (1891), Askanazy (1900)], although Calmette (1893) suspects
that the parasite may give rise to substances acting as chemical
irritants.

**CLINICAL MANIFESTATIONS.**

The clinical picture described by Normand (1877) in his cases of
Cochin China diarrhoea is that of a chronic diarrhoea, rather than of
a dysentery. This commonly begins with mild dyspeptic symptoms,
eructations, loss of appetite, etc., and a diarrhoea of moderate intensity,
the stools being soft and pasty—three or four a day; the actions are
often more frequent in the early morning hours. Not uncommonly,
this condition is interrupted by temporary exacerbations; the attacks
are sometimes dysenteric in character, the stools showing mucus and
blood; in other instances more choleraic, the dejecta consisting of an
abundant flux of a liquid yellowish material, while there may be
vomiting, cyanosis and collapse. In many instances recovery occurs
early in the course of the disease, the symptoms gradually clearing up.
In other cases the patients pass on to a condition of extreme emaciation
with great prostration. The anaemia is not, as a rule, very severe.
Intercurrent dysentery is not uncommon and may terminate fatally.

Barbagallo (1897) and de Silvestri (1895) have reported cases in
which certain nervous manifestations (headache, vertigo, tinnitus
aurium, feeling of prostration) played a prominent part in the clinical
picture. In de Silvestri's case there were no intestinal symptoms.
All these manifestations ceased with the disappearance of the parasites
under treatment with male fern.
TREATMENT.

The treatment, beyond those measures of rest and diet such as are applicable to all similar conditions, is not especially satisfactory. Normand (1877) fancied that the use of large quantities of olive oil was of a certain value purely from its mechanical action.

Perroncito (1881) believed that he had obtained results from large doses of the ethereal extract of male fern, doses as large as 12 grammes repeated daily until the disappearance of the parasite. In other instances he gave from 15-30 grammes in three doses during the morning, and repeated these daily, until the disappearance of the parasites from the stools. De Silvestri (1895) and Barbagallo (1897) in single cases, also report good results from the use of male fern. Perroncito insists particularly upon full and repeated doses, and believes that the failure to obtain good results depends upon the fact that observers have used insufficient quantities of the drug through too short a period of time.

On the other hand, Seifert (1883) found that, in doses as large as 20 grammes, the ethereal extract of male fern was without effect. He obtained better results from large doses of thymol.

Grassi (1883) also vigorously opposes the view that any known anthelmintic is of particular value in the treatment of this disease. This is based upon his own experience and upon the fact that adult parasites are hardly ever found in the stools even after the administration of large doses of the drugs.

Golgi and Monti (1884, 1885) and Riva (1891) also found that repeated and large doses of these anthelmintics appeared to have little or no result.

CASES.

The three cases which are here briefly reported are, I believe, the only instances which have been observed in the United States.

The first of these occurred in the Johns Hopkins Hospital nearly four years ago, and was recognized and studied by R. P. Strong, who was, at that time, a fourth-year medical student. Lieutenant Strong, who is now the director of the U. S. Army Pathological Laboratory
William Sydney Thayer

at Manila, has made a careful study of this case, which will be reported later by him, in the Johns Hopkins Hospital Reports.* He deserves entire credit for the discovery and recognition of the first instance of this disease noted in this country.

CASE I.—Amoebic dysentery. Intestinal infection with Trichomonas intestinalis and Strongyloides intestinalis. Abscess of the liver. Death. Autopsy. K., a German tailor, aged 52, was admitted to the Johns Hopkins Hospital December 7, 1896, complaining of pain and swelling in the right side of the abdomen and over the lower ribs.

The family history was negative. He had had measles in childhood, but had, otherwise, been a healthy man. He denied venereal disease. Up to six years before he had lived in Austria.

Three years before entry, he began to suffer from diarrhoea which has continued since that time. There were, daily, from two to five operations, which occasionally contained a little blood; these were never associated with pain. Three weeks before entry, he began to notice a painful swelling on the right side over the lower ribs. He had had no chills, and, so far as he knew, no fever. For two weeks before entry, there had been a slight cough without expectoration.

On physical examination the patient appeared emaciated and feeble. The heart and lungs were negative. The abdomen was somewhat distended; there was slight movable dulness in the flanks. On the right side, over the cartilages of the tenth and eleventh ribs, there was a large fluctuating swelling, 7½ cm. in diameter; no tenderness or redness. Between this and the spinal column there was another swelling, about 15 cm. in diameter, extending from the median line to the spinous processes, and from the twelfth rib over the crest of the ilium, downward for a distance of 7 cm. The skin over this was adherent, red and thin. The hepatic flatness was not increased.

Immediately after entrance this abscess was incised and evacuated. The cavity contained a large amount of thick puriform material with dark shreds and considerable greyish debris. The cavities extended into the liver. About one and a half pints of fluid were evacuated; this contained many large, actively motile amoebae, showing the ordinary characteristics of Amoeba coli.

The patient had daily, from one to four fluid, brownish, foul-smelling stools, which contained, besides Amoeba coli, considerable numbers of Trichomonas intestinalis, as well as numerous small nematodes identified by Mr. Strong as the rhabditiform embryos of Strongyloides intestinalis.† The wound and the colon were irrigated with a solution of quinine, 1/1000.

The patient gradually failed and died on December 26.

* Since the completion of this article Strong's paper has been published. (See Bibliography.)
† The conclusions of Mr. Strong were confirmed by Dr. Charles Wardell Stiles of the U. S. Bureau of Animal Industry.
The protocol of the autopsy reads: "Amoebic dysentery; ulceration of the large intestine; retroperitoneal abscess; operation wounds; parenchymatous and fatty degeneration of the kidneys; fatty liver; fatty heart; intestinal infection with *Trichomonas intestinalis* and *Strongyloides intestinalis*.”

"The abscess cavity measured 7 x 5 cm. on the surface of the liver and extended about 4 cm. into the substance of the organ. Scrapings from the wall showed numerous amoebae.” The rectum and colon are the seat of widespread ulceration. The ulceration, which, for the most part, is shallow, leads in the rectum, into an eroded, thickened, hemorrhagic appearance. The ulcers vary in size; the largest are irregular in shape, measuring about 3 cm. in length by 2 in width. A typical ulcer of moderate size might be described as follows: “Shallow, smooth base, somewhat striated, evidently formed by the muscular coat of the intestine; white and shining, covered with whitish shreds. The outline of the ulcer is irregular but rather clean-cut, the edges are slightly elevated and are hemorrhagic, neither shredded nor undermined.” There are a large number of small pea-sized, and smaller, yellowish, slightly elevated areas, with red margins, which on careful study, appear as shallow ulcers, filled with a tenacious yellowish material. As they grow larger, they become like the typical one described above. About the middle of the transverse colon are two perforating ulcers, rather more hemorrhagic about the edges; the mucous membrane is turned outward. Coverslips from the ulcers show active amoebae. The small intestine is free from ulceration; here and there is a slight ecchymotic patch. The abscess of the liver communicates with the large retroperitoneal abscess opening outward as first described.

All along the tract Mr. Strong and Dr. Stiles found embryos of *Strongyloides intestinalis*. The parthenogenetic mother worms were found in the duodenum and jejunum. Careful studies by Mr. Strong resulted in the cultivation of but one adult male of the free living generation; adult females were never found. The direct transformation of the rhabditiform embryos into the filariform larvae was apparently the rule. A similar observation has been previously made by Grassi and Segrè (1887), who found that, when the direct transformation predominated, the sexually differentiated forms found in the cultures were always males.

The point of origin of the infection in this case was not apparent. The disease may have been brought from Austria. The patient lived in the city, and drank city water.

**Case II.—Chronic diarrhea. Rhabditiform embryos of Strongyloides intestinalis in the dejecta. Great improvement.**

N. P., a boy seventeen years old, presented himself at the dispensary of the Johns Hopkins Hospital May 10, 1899, complaining of diarrhea.
The family history was good. There was no history of pulmonary trouble or of hereditary disease. The grandmother, however, had suffered from diarrhoea for five years.

Personal History.—The patient had lived all his life in Richmond, Virginia, where he had been a newsboy. He had had measles, whooping cough and mumps as a child, and had suffered, off and on, from indefinite pains in both legs. Five years before entry, he had tertian ague. There was no history of pneumonia, typhoid fever, acute rheumatism, pleurisy, scarlet fever or chorea.

Present Illness.—Three years before entry, the patient began to suffer from diarrhoea, the attack coming on during the summer. The operations were very thin and yellowish in color, containing at times, a small amount of blood, though this had not been noticed for a year and a half. The passages occurred mainly at night, as many as seven or eight in twenty-four hours, but of late, only about four. There was, at first, considerable mucus in the stools, but this had been practically absent during the two years before entry. The diarrhoea had never been associated with pain. The patient, however, had grown gradually weaker, and during the second year of his illness, he had been compelled, on one occasion, to take to bed for two weeks. Four months before entry, he gave up work on account of weakness, though up to that time he had felt tolerably well.

The appetite was good; there were no dyspeptic symptoms.

Physical examination showed a slight, emaciated boy, of sallow color. The lips and mucous membranes were somewhat pale; tongue clean. The chest was long and narrow; the intercostal spaces, deep. Examination of the heart and lungs was negative. The abdomen was not distended. The spleen was not palpable. No peristaltic movements were visible. There was an irregular chloasma-like pigmentation over the cheeks, forehead and temples, and also over the lower thorax and lateral abdominal regions.

The urine showed no abnormalities.

The blood showed no marked leucocytosis; no apparent increase in the eosinophilic cells.

A rectal tube was introduced and a little, brownish, foul-smelling material was obtained which, besides muscle fibres, vegetable cells, granular debris and bacteria, contained a number of actively motile worms. In the fresh stools these measured all the way from 0.225 to 0.45 mm. in length by 0.02 to 0.03 mm. in breadth. They showed the characteristic structure of the rhabditiform embryos of Strongyloides intestinalis, and manifested a very active serpentine motion.

The worm diminished slightly in size toward the head, and gradually tapered down to a slender sharp-pointed tail. The periphery was somewhat refractive, while within, the substance was filled
with glistening, refractive, fat-like granules, which were rather larger toward the head than toward the tail. The digestive tract was clearly visible. The oesophagus, between one-third and one-fourth the length of the worm, showed a long bulb-like enlargement at the head, followed by a constriction, which was succeeded by a second, round or ovoid enlargement. The digestive canal was readily seen to pass through these enlargements, the anal outlet being situated at a distance equalling about one-tenth the length of the worm from the tip of the tail. The anterior lip of the anal outlet was slightly raised. The mouth of the worm appeared, as far as could be made out, to consist of a simple funnel-shaped depression. In some instances the lumen of the digestive canal appeared to pass, as a straight line, directly through the oesophageal enlargements. In others, a distinct triangular opening was to be seen in the middle of the second of the oesophageal enlargements; the outlines of this opening were glistening and refractive, indicating clearly the tridentate, chitinous armature described by other observers (Plate IX, Fig. B). In many of the active worms repeated and violent muscular contractions of the oesophagus were observed; these were especially marked about this tridentate opening, which appeared to open and shut with considerable force. The outlines of the cells bordering the digestive tract, of which, in some instances, a slight suggestion could be made out, were as a rule entirely hidden by the glistening granules above mentioned. A little below the middle of the worm, on the same side as the anal opening, was a small clear elliptical area—the rudiment of the sexual apparatus.

The boy refused to enter the hospital, and was observed in the out-patient department off and on up to June 21. As far as possible he was kept in bed, placed upon a liquid diet and given large doses of bismuth. On May 21 he was given santonin 0.25 (gr. IV) followed by castor oil, but no adult worms were found in the discharges. He was also given high rectal irrigations with a 1/2500 solution of quinine; on several occasions thymol was administered, a dose of 2. (gr. XXX) being given on successive hours, followed by a castor oil purge.
The diarrhoea gradually diminished and the stools became semi-solid in character, but still contained parasites.

No adult forms of the worm were ever found. The parasites always died a few hours after the stools were obtained, possibly owing to the fact that urine was mixed with the dejections.

On June 21, the patient went home, but returned to the hospital on July 7. He was immediately put to bed, and given a liquid diet.

The stools, at this period, were from three to four in number in the twenty-four hours. They were at first of a pea-soup consistency, having a peculiar, foul smell, and showing considerable numbers of the rhabditiform embryos.

For a time the only medicinal treatment consisted of large doses of bismuth.

The stools were collected, free from the urine, and various culture experiments were made. In some instances the feces were placed in the thermostat and kept at body temperature. In others, they were kept near the thermostat at a temperature of about 30-35°C. Other specimens were kept at room temperature, 20-30°C. When but few parasites were present, the method suggested by Leichtenstern (1898) was followed. In the semi-solid or solid feces an excavation was made into which a little water was poured. Some hours later considerable numbers of parasites were usually to be found in this fluid. The best results were obtained in those cultures made at a temperature of 30-35°C.

The smallest worms, found immediately after the passage, measured about 0.22 mm in length. During the next several hours they were observed to grow considerably until the largest measured about 0.55. Within twelve hours the greater number of the worms in the cultures had lost the distinct oesophageal enlargements, and had become somewhat longer and more delicate in structure, measuring usually from 0.4 to 0.55 mm in length and, in one recorded instance, as much as 0.7 mm. Sometimes examples were found measuring under 0.4 mm. The transverse measurement was from 0.016 to 0.022 mm. All trace of the rudiment of the sexual gland disappeared. The anal opening was not evident and the digestive tract was visible.
only through about half the length of the worm. In the posterior half of the worm the granules were darker and apparently more abundant than in the anterior portion. Though the parasite, as a whole, was more delicate than the younger embryo, the tail, as shown in the drawing (Plate IX, Fig. C), was blunter, and more truncated.* The parasites became rather more active, showing most striking serpentine movements, the appearance coinciding entirely with that of the filariform larvae of *Strongyloides intestinalis.*

Though the stools were carefully studied during the patient’s entire stay in the hospital from July 7th to August 26th, and though cultures were made daily, no examples of the sexually differentiated, free living generation were found.

In many of the specimens, worms were seen in which the outer layer had the appearance of a refractive capsule, but no constant relation between this appearance and the development of the parasite was traced. The moulting or escape of the parasite from this capsule was not observed.

In one or two instances the worm was noted, under observation, to become suddenly motionless, while the capsule became shrunken and greatly wrinkled. The finer points in the internal structure of the worm were no longer to be made out.

Although, as has been noted, the stools were examined several times a day through a long period of time, only two eggs were observed. These were similar in appearance. Drawings and measurements were made of one seen on the twenty-fifth of May.

These eggs were of elliptical shape, with a thin, clear, yellowish shell, and granular contents which could be clearly seen to be in segmentation. The measurements were about 0.0675 by 0.0375 mm. The appearances have been admirably reproduced by Broedel in Plate IX, Fig. A.

The condition of the patient improved greatly during his stay in the hospital. During the greater part of the time, he received subnitrate of bismuth 1.3 grn. (grains XX) three times a day. On several occasions thy-

* The truncation of the tail was not noted in the detailed observations, which were made before a careful study of the literature was undertaken. In the admirable drawings, however, made from life by Broedel, this point is clearly brought out.
mol was given, in two doses of 2. (gr. XXX) each, and on July 28 the patient took two doses, separated by an interval of an hour, of 4. (3) each, of fluid extract of male fern, followed by a purge. Neither eggs nor mother worms were found in the stools. The stools gradually became more solid, though never formed; they diminished in frequency until, finally, there were only one or two in the twenty-four hours. The diet was gradually increased, and, on July 24, he was allowed the regular ward diet. On August 28 the patient was, at his own request, discharged; he had gained twenty-two and one-half pounds in weight. On discharge, however, the pasty stools still showed moderate numbers of the rhabditiform embryos. Through friends of the patient it has been learned that he has, since this time, regained his normal weight and strength. He has resumed his occupation and considers himself well.


J. S., a farmer, a native of Anne Arundel County, Maryland, was admitted to the Johns Hopkins Hospital July 19, 1900, complaining of diarrhoea and swelling of the feet.

Family history, good.

Personal History.—The patient had been a farmer all his life; his habits had been good; he had had no serious illnesses, excepting chills and fever fifteen years before entry. He had always lived in Anne Arundel County, having never been out of the State of Maryland, excepting for occasional visits to Washington.

Present Illness.—He had considered himself a healthy man up to six months ago when he began to suffer from diarrhoea and progressive weakness. The stools, very frequent and sometimes involuntary, were fluid but never contained blood. They were small in quantity. During two months before entry, the patient had, on several occasions, vomited a yellowish fluid. For two days he had had sharp, griping pains in the lower abdomen. For a month there had been oedema of the feet and legs.

There had been no increase in the quantity of urine, though there was increased frequency of micturition. During the last two months he had lost considerably in weight and much in strength.

The examination by Dr. Futcher, on January 20, showed a rather sparcely nourished man with a sallow complexion; moderate thickening of the radial arteries; no arcus senilis. Physical examination of the lungs was negative. Heart sounds, feeble, but free from murmurs. The abdomen was slightly full, bulging in the flanks, everywhere flat excepting in the umbilical region, where there was tympany; hepatic flatness, continuous with the abdominal flatness.

On July 19, a count of the leucocytes showed 21,500 to the cubic millimetre. Rectal examination showed numerous external hemorrhoids; the mucous membrane felt rather soft; the prostate was enlarged and firm.

The dejecta were fluid, containing considerable pus, great numbers of leucocytes, a few red blood corpuscles and a moderate number of characteristic rhabditiform embryos of Strongyloides intestinalis.

The urine showed, throughout, a rather low specific gravity, 1005-1015, a trace of albumin, and occasional hyaline and granular casts. The quantity was not accurately estimated.
The temperature was slightly elevated, 100.6°, on entry, but, with the exception of an occasional rise to a point between 99° and 100°, it remained sub-normal during the greater part of the patient's sojourn in the hospital.

On July 26, a blood count showed: Red blood corpuscles 3,560,000; hemoglobin 57%.

On entry the patient was given a milk diet, and powders containing:

Tannogen 0.65 grn. (grains X), bismuth. subnit. 2. (gr. XXX) every four hours; also diuretin, citrate of potassium and strychnine. On the following day, the medicines, with the exception of the strychnine, were omitted.

On the 24th, tannogen 0.65 (gr. X) every four hours, was again ordered, as well as diuretin 0.325 (gr. V) every four hours.

There was little improvement in the condition of the patient up to August 12, on which date he was given thymol 0.325 (gr. V) every four hours, which resulted in an apparent improvement for about two weeks, after which time the diarrhea returned. On August 21 the tannogen was discontinued, and the patient was given subnitrate of bismuth 1.3 (gr. XX) every four hours. On August 31 the bismuth was omitted and the tannogen was discontinued again September 4, and salol 0.325 (gr. V) every four hours was ordered. On August 13, the thymol was discontinued and four doses of santonin were given at hourly intervals without any striking results. The number of movements, however, became somewhat reduced and the general condition of the patient was considerably better. There was a gain of twenty-one and a half pounds in weight between July 29 and September 17, the date of his discharge.

Cultures from the faces, made according to the same methods as in the last case, showed the direct transformation of the rhabditiform embryos into the filariform larvae; the change was complete, in many instances, within twelve hours. No adult forms of the sexually differentiated, free-living generation were observed. No eggs were found in the stools, nor were any examples observed of the parthenogenetic mother worm.

These three cases are interesting in that they are the first which have been observed in this country. Of especial importance is the question regarding their point of origin. In the first case it is possible, though scarcely probable, that the disease may have been acquired in Austria. In the second and third, however, the disease must have originated here.

The behavior of the parasite on culture was similar to that commonly observed in cases arising in temperate climates. In all three cases, the direct transformation of the rhabditiform embryos into the filariform larvae predominated. In one instance only, was a single
sexually differentiated form of the intermediate, free generation observed.

Question might be raised with regard to the nature of the eggs observed in Case II. The size of the one in which measurements were made, exceeded that attributed to the eggs of the parthenogenetic mother worm by many authors. Thus, Grassi and Parona (1879) give the measurements of the eggs as 0.06 x 0.04 mm., while Bráun (1895), in his manual, gives the measurements as 0.050 to 0.058 x 0.030 to 0.034 mm., and Railliet (1895) gives the same measurements. Again, most authors are unanimous in stating that the eggs are present in the stools only with the greatest rarity.

There can, however, be little doubt as to the nature of the two eggs observed in this case.

(1) In the first place it will be remembered that they were found only upon two occasions, although a careful daily search was made through several months. Moreover, all authors who have had much experience with the parasite, have noted the occasional presence of eggs in the fresh stools.

(2) Their general conformation agreed entirely with that of the eggs of the parthenogenetic mother worm.

(3) The measurements, though larger than those given by Grassi and Parona and in most text-books, agree, however, with those given by Golgi and Monti (1884, 1885) in their careful and accurate study, and also by Riva (1891). These observers state that the diameters vary from between 65 and 70 μ in length, by 30-39 μ in breadth.

Another objection which might be opposed to the assumption that these were eggs of Strongyloides intestinalis, is the fact that, in each instance, they were in the process of segmentation, and did not yet contain the completely developed embryo. Might they possibly have been the eggs of Uncinaria duodenalis? This can be easily ruled out, both on account of their greater size, as well as because of the fact that they were found on but two occasions. In uncinariasis the eggs are always numerous.

They could not have belonged to the sex-ripe intermediate generation; (1) because, on careful search, the adult parasites were never
found; (2) because they were found in fresh stools. It may not be impossible that these special examples may have represented eggs in which the process of development had, for some reason, been arrested.

Another question which arises in connection with this case is the following: Do these instances represent an outbreak of the disease due to parasites which have been imported within recent years, or are we to assume that this worm has long existed among us?

When one considers the infrequency with which systematic examinations of the feces are made, it seems to me unnecessary to assume that the worm has been recently imported. It is highly desirable that, both in our hospitals and in private practice, more systematic and thorough examinations of the feces should be undertaken than are at present customary. It is safe to say that if microscopical examination of the feces were carried out as regularly and systematically as is the microscopical examination of the urine and the blood, a number of interesting and important observations would follow.

An especially interesting point in connection with the history of this parasite is its frequent association with *Uncinaria duodenalis*. Grassi (1879) early emphasized the frequency of combined infections, while Perroncito (1880–4, 1881, 1882, 1883), Sahli (1882), and others have also brought out this fact in connection with their studies of the epidemic among the workers in the St. Gothard Tunnel. Of 30 of Grassi's autopsies in Milan in which *Anguillula intestinalis* was found, *Uncinaria* was also present in 25. Lutz (1885) in Brazil, in 35 cases of infection with this parasite, found a combined infection with *Uncinaria* in 30, or 85.7%. The conditions under which the two parasites flourish seem to be similar, and the discovery that one of the worms exists among us, should open our minds to the possibility of the presence of the other.* Especially should it emphasize the importance of a careful examination of the stools in all suspicious cases of anaemia.

*While this article is in press, Dr. John L. Yates, Assistant in Pathology, Johns Hopkins University, has discovered at autopsy a case of Uncinariasis (Anchylostomiasis) at the Baltimore City Asylum at Bay View.*
The relation of the parasite to the diarrhoea in these three instances is somewhat questionable. In Case I, the exciting cause of the process is uncertain, the parasite having been associated with *Amoeba coli*. In Cases II and III, however, there was no apparent cause for the diarrhoea other than the presence of these nematodes. And while, in both instances, the parasites were present upon the discharge of the patient, improvement was associated with a great reduction in their number.

In conclusion one may be justified in emphasizing the following points:

(1) Diarrhoea associated with the presence of *Strongyloides intestinalis* occurs in the United States.

(2) The observation, in the Johns Hopkins Hospital, of three cases within three years, cases originating probably in Maryland and Virginia, suggests that this parasite may be more frequent than has hitherto been supposed.

(3) As in most cases originating elsewhere, in temperate climates, the development of the sexually differentiated, free living generation was in these instances apparently unusual, the direct transformation of the rhabditiform embryos into filariform larvae predominating.

(4) The discovery of the existence of *Strongyloides intestinalis* should emphasize the possibility that *Uncinaria duodenalis* may also occur in this country.

(5) More systematic examinations of the faeces both in public clinics and in private practice are much to be desired.

**BIBLIOGRAPHY.**


Bavay, 1877. (1) Sur l'anguillule intestinale (*Anguillula intestinalis*), nouveau ver nematoide trouvé par le Dr. Normand chez les malades atteints de diarrhée de Cochinchine. Ibid., 1877, lxxxiv, 266.
Bavay, 1877. (2) Note sur l’anguillule intestinale (*Anguillula intestinalis*), nouveau ver nématode trouvé par le Dr. Normand chez les malades atteints de diarrhée de Cochinchine. *Arch. de méd. nav.*, Par., 1877, xxvii, 64.


Blanchard, 1890. Traité de zoologie médicale, Paris, 1886-90, t. ii, 70.


Bozzolo. See Pagliani and Bozzolo.

Braun, 1895. Die tierischen Parasiten des Menschen, etc. Würzburg, 1895, 215.

Breton, 1879. Note sur les parasites de la dysenterie et de la diarrhée dite de Cochinchine. *Arch. de méd. nav.*, 1879, xxxi, 411.


Calandruccio. See Grassi and Calandruccio.

Calmette, 1893. Étude expérimentale de la dysenterie ou entéro-colite endémique d’extrême orient et des abcès du foie d’origine dysentérique. *Arch. de méd. nav.*, 1893, ix, 207, 261, 335.


Davaine, 1877. Traité des entozoaires et des maladies vermineuses de l’homme et des animaux domestiques. 2me éd., Paris, 1877.

Dounon, 1877. Étude sur l’anatomie pathologique de la dysenterie chronique de Cochinchine. *Arch. de physiol. norm. et path.*, 1877, 2. s., iv, 774.


Fontan. See Bertrand and Fontan.


Golgi and Monti, 1885. Sulla storia naturale e sul significato clinico-patologico delle cosi-dette anguillule stercole e intestinali. Atti d. r. Accad. d. sc. di Torino, 1885, xxi, 55. Also, Arch. per le sc. med., Torino, 1886, x, 93.


Strongyloides intestinalis in the United States


Laveran, 1877. (1) Note relative au nématode de la dysenterie de Cochichine. Gaz. hebdom. de méd. 1877, 2 s., xiv, 42.


Leuckart, 1886. The Parasites of Man, &c., Edinb., 1886. (Translated by W. E. Hoyle.)


Libermann, 1877. (2) Observations de diarrhée de Cochichine suivie de quelques réflexions. Union méd., 1877, 3 s., xxiii, 737.


Monti. See Golgi and Monti.


Neumann, 1892. Parasites and Parasitic Diseases of Domesticated Animals. Lond., 1892, 387. (Translated by George Fleming.)


* This article is surprisingly incorrect in text, references and figures.


Peiper. See Moser and Peiper.


Perroncito, 1880. (3) Osservazioni elmintologiche relativi alla malattia sviluppatisi endemica negli operai del Gottardo. *Atti e rendiconti della r. Accad. dei Linc.* Roma, 1879-80, Anno celxxvii, s. 3^a, mém. della class. d. sc. fis., mat. e nat., vii, sed. 2 (Magg.).


Perroncito, 1880. (5) On the action of chemical agents and medicinal substances on the larvae of Dochmius duodenalis and Anguillulae; including therapeutical considerations relative to the cure of patients from Mont.-St. Gothard. *Veterinarian*, Lond., 1880, liii, 824.


Perroncito, 1882. Les ankylostomes (ankylostome duodenale de
Strongyloides Intestinalis in the United States


Raillet, 1895. Traité de zoologie médicale et agricole, Par., 1895, 2me édition, 557.


Schneidemühl, 1895. Lehrbuch der vergleichenden Pathologie und Therapie, Leipzig, 1895, 305.

Segrè. See Grassi and Segrè.


William Sydney Thayer


Strong, 1901. (2) Cases of infection with Strongyloides intestinalis (first reported occurrence in North America). The Johns Hopkins Hospital Reports, 1901, x, 91. (Both of these articles were published after completion of this paper.)


Weichselbaum, 1898. Parasitologie, in Weyl’s Handbuch der Hygiene, 1898, ix, 2 Lief., 317.


DESCRIPTION OF PLATE IX.

These figures were drawn from life by Max Broedel, Leitz, Objective 7, Ocular 3.

A. Egg of Strongyloides intestinalis (parasitic mother worm) found in stools of Case II, on May 35, 1896.

B. Rhabditiform embryo of Strongyloides intestinalis from the stools.

C. Filariform larva of Strongyloides intestinalis derived, by direct transformation, from a rhabditiform embryo.