CHARACTERISTICS OF BLOOD FILARIÆ.

Species	*F. diurna*	*F. nocturna*	*F. perstans*	*F. volvulus*	*F. Demarquayi*	*F. Ozzardi*
Length	0.300 mm.	0.300 mm.	0.230 mm.	0.250 mm.	0.205–0.210 mm	0.17–0.24 mm.
Breadth	7.5 μ.	7.5 μ.	4.5 μ.	5 μ.	5 μ.	4–5 μ.
Sheath	Present	Present	Absent	Absent	Absent.	Absent.
Head	?	Six-lipped armature	Papillated	Rounded	Retractile spine	
Tail	Sharp	One-fifth taper (sharp?).	Truncated.	Sharp, one-fifth taper.		Sharp.
Body	Central granular mass.	Indistinct central granular mass.	No central granular mass.	Central granular mass.		
"V" spot	Present.	Present	None	Clear spot	Present, 0.052 mm.	

ple ovary; vulva at junction of the two regions of the body; eggs with peculiar translucent plug in the shell at each pole. Development direct and without ecdysis.

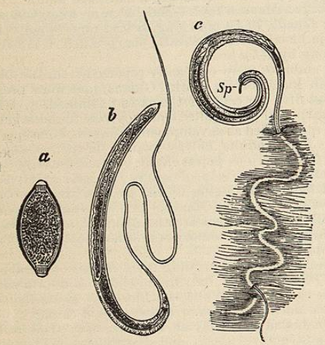

FIG. 3551.—*Trichocephalus trichiurus*. *a*, Egg; *b*, female; *c*, male with anterior end embedded in mucosa; *sp*, spicules. (After Claus.)

Of the half-dozen genera only two are important here, but they include two of the commonest and the most feared of human parasites.

Trichocephalus Goeze 1782.—Anterior region very long and filiform; posterior region, which contains the intestine and reproductive organs, short, sharply set off from anterior and markedly inflated. In the male it is rolled into a spiral; one spiculum with infundibuliform sheath. In the female the posterior regions are lightly bent, but not in a spiral. Parasitic in the large intestine and cæcum of mammals.

Trichocephalus trichiurus (L. 1771).—(Syn.: *Ascaris trichiura* L. 1771; *Trichocephalos* Goeze 1782; *T. hominis* Schrank 1788; *T. dispar* Rud. 1801; *Mastigodes hominis* Zeder, 1803.)

Male, 40–45 mm. long, with strongly attenuated anterior region comprising three-fifths of the total length. Spicule single, 2.5 mm. long, located in a spinous protractile sheath; posterior region in a flattened spiral. Female, 45–50 mm. long, with attenuated anterior region two-thirds of total length. Eggs, 51–53 μ long by 21–23 μ wide, brownish, thick-shelled, with polar knobs, and deposited before cleavage begins (Fig. 3551).

The striking appearance of this genus, a single species alone of which is parasitic in man, is due largely to the regions of the body. The filiform region contains only the œsophagus, leaving the remainder of the alimentary canal and all the reproductive organs for the greatly enlarged posterior region in which the transparency of the body wall permits one to recognize the various structures even in the living worm. The orifice of the vagina lies near the level of the transition from œsophagus to midgut.

Life History.—The eggs are produced in large numbers, four hundred thousand annually by a single female (Leuckart), and undergo no development until they have passed out of the human body. Cleavage takes place in water, but only at the end of some months or even more than a year. The eggs are well protected by the heavy shell from adverse circumstances, so that Davaine has kept embryos living within them for five years. The introduction of these embryos still within the shell is ordinarily brought about through drinking-water, though Blanchard suggests the evident possibility of their introduction on salads and uncooked vegetables. In the human stomach the shell is dissolved and the embryos are set at liberty to reach sexual maturity at the end of a few weeks, as has been definitely established by the experiments of Grassi.

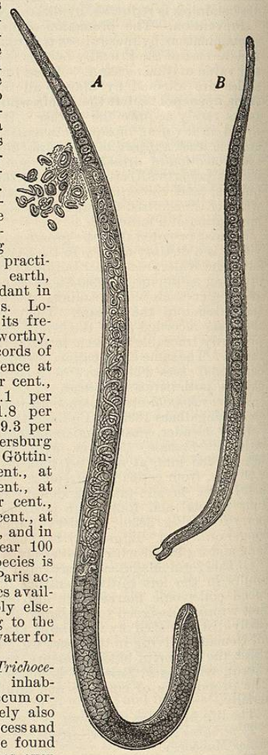

FIG. 3552.—Intestinal Trichina. *A*. Female with embryos; *B*, male, × 80. (After Heller.)

Distribution.—This is one of the commonest parasites of man, being distributed over practically the entire earth, though more abundant in the warmer regions. Local variations in its frequency are noteworthy. Braun cites, as records of autopsies, its presence at Dresden as 2.5 per cent., at Erlangen 11.1 per cent., at Kiel 31.8 per cent., at Munich 9.3 per cent., at St. Petersburg 0.18 per cent., at Göttingen 46.1 per cent., at Basel 23.7 per cent., at Greenwich 68 per cent., at Dublin 89 per cent., at Paris 50 per cent., and in Southern Italy near 100 per cent. This species is growing rarer in Paris according to statistics available, and probably elsewhere also, owing to the disuse of surface water for drinking.

Pathology. — *Trichocephalus trichiurus* inhabits the human cæcum ordinarily, but rarely also the vermiform process and colon, and may be found in persons of all ages, even occurring in infants of a year old.

Usually only a few individuals are present in a single host, but in some cases as many as one thousand parasites have been found at

once. Normally they occur with the filiform anterior region embedded in the mucosa, and recent investigation tends to demonstrate that such as are found free in the canal have been driven out by post-mortem changes.

This species has been regarded earlier as playing a pathogenic rôle in typhoid, cholera, and beri-beri, and more recently all pathogenic significance has been denied it. Though the presence of a few does not occasion pathogenic symptoms, yet since Askanazy has shown the occurrence of hæmoglobin in the alimentary canal of these worms, the fact that they nourish themselves on the blood of the host cannot be doubted. In occasional severe cases noteworthy depression, suppression of the urine, with fever, cardiac weakness, and often nervous symptoms, have been noted.

Treatment is said to be difficult, and naphthalin, thymol, and peletierine have been used with only moderate success. A later writer commends santonin as rapid and effective.

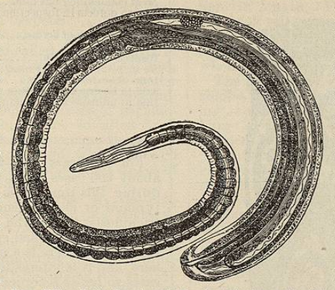

FIG. 3553.—Fully Developed Muscle Trichina with Alimentary Canal and Genital Primordium, Removed from Cyst. Magnified. (After Leuckart.)

Prophylaxis.—Care in obtaining drinking-water and in selecting and cleansing uncooked vegetables will evidently limit the spread of the parasite.

Trichinella Railliet 1896. — (Syn.: *Trichina* Owen 1835.)

Very small, slender, without marked distinction of regions in body. Male without spicule, but with lateral appendages at posterior end, as if a poorly developed bursa were present. Female ovoviviparous; vulva at anterior fifth of body. Only a single species.

Trichinella spiralis Raill. 1896.—(Syn.: *Trichina spiralis* Owen 1835.)

Male (Fig. 3552, *B*), 1.4–1.6 mm. long by 0.04 mm. broad, without spicules, but with a short conical appendage on either side of the cloaca, behind which are two pairs of papillæ. Female (Fig. 3552, *A*), 3–4 mm. long, 0.06 mm. broad; vulva ventral near anterior fifth of body; anus terminal, viviparous. Fully developed larva, 0.8–1 mm. long by 0.04 mm. broad; cyst measures 0.4 by 0.25 mm.

The sexually mature parasite, sometimes called the intestinal trichina, inhabits the small intestine of man and various other mammals. The larval form, known as the muscle trichina, is found encysted in muscular tissue.

FIG. 3554.—Encapsulated trichina. (After Leuckart.)

Easily infected are man, pig, rat, mouse, guinea-pig, rabbit; less easily sheep, calf, horse; with difficulty cat, dog, badger. The intestinal form will develop also in birds, but the embryos are expelled with fæces and do not reach the muscles.

History.—Encysted trichinæ were first noted by Peacock in London as early as 1828, but it was 1835 before their character as encapsulated entozoa was recognized by Paget and the parasite described by Richard Owen. The presence of encysted trichinæ in man was confirmed by a multitude of observations from various countries, and Joseph Leidy added a most important fact in the discovery of similar worms in pork. Feeding experiments by Leuckart, Virchow, and Küchenmeister, together with the observations of Zenker on a maid that had died of apparent typhoid, led to the elucidation of the life history and to proper estimation of the pathogenic character of the parasite which had heretofore been regarded as harmless or as the immature form of a *Trichocephalus* or *Strongylus*. Rapid accumulation of isolated cases and of epidemics of trichinosis, almost all from North Germany, placed beyond question the etiological significance and importance of the trichina.

Life History.—If a portion of flesh containing the larval worms is eaten by a suitable host, the larvæ are set free in the stomach and pass into the small intestine. They attain sexual maturity in about two and one-half days, copulate, and the male soon dies. Two opposed views as to the dispersal of the young have long been held. According to one the migration of the embryos is an active one in that they bore their own way out of the canal and through the connective tissues to their ultimate seat. The other view, however, of passive transport by the blood and lymph streams may be regarded as demonstrated by recent work, particularly that of Graham, whose account is followed in the main here. The gravid female bores into the intestinal wall as far as the lymph vessel. There the young are produced, being set free by the female into the lymph stream, which carries them ultimately into striated muscle tissue. At birth they measure 0.09–0.11 mm. in length by 5–6 μ in width, and at the close of this migration but little more, being then 0.12–0.16 mm. long. In eight days these embryos are in the intramuscular connective tissue and only a few days later in the muscle fibres themselves (Fig. 3555). The fibres lose their transverse striation and undergo granular and fatty degeneration. The embryo increases rapidly in size, and rolls into a loose spiral in an expansion of the completely degenerated fibre. By the action of the surrounding connective tissue, in which connective-tissue corpuscles and leucocytes are contained, a cyst of characteristic form is produced (Fig. 3554). It is thickened at the poles and measures about 0.4 mm. by 0.25 mm. in diameter. This process occupies several weeks, during which later broods of embryos are produced, since each female lives five to seven weeks and gives birth to from eight thousand to ten thousand young. Thus in the early stages of an infection one finds in the muscle embryos in various stages of development and encystment, side by side.

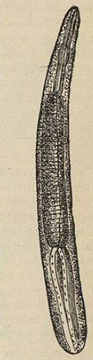

FIG. 3555.—Muscle Trichina Fifteen Days After Infection. × 165. (After Leuckart.)

Once encysted the larvæ remain quiescent; it may be for long periods. Thus encysted trichinæ have been found living in human muscle, twenty-five and even thirty-one years after the presumed infection. Not infrequently, though perhaps not always, one finds evidences of further change in the formation of a delicate calcareous layer about the cyst (Fig. 3556). In some cases this encroaches upon the larva so as to produce ultimately a calcareous nodule in which a remnant alone of the worm is contained. It is held by some that calcification does not ensue until after the death of the larva from unknown causes. Fatty degeneration of the encysted trichinæ can also be observed, and is likewise held to be a pathogenic process. Such larvæ as rarely occur in connective tissue are without the characteristic cyst, but appear to be smothered in a mass of proliferating connective tissue.

While it has been determined experimentally that a considerable number of hosts furnish conditions favorable for the development of the trichinæ, the normal host is no doubt the rat, and evidence has been adduced to prove the introduction of this parasite into Europe from

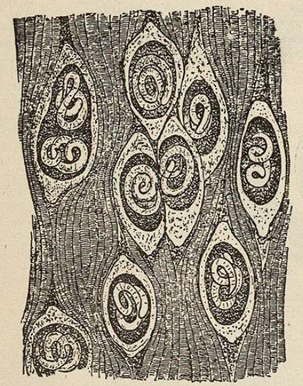

Fig. 3556.—Muscle with Encysted Trichinæ in Process of Calcification. (After Braun.)

the East with the brown or Norway rat. The method of transmission in this species is clear when one recalls that rats are cannibals and universally make way with aged or infirm members of the tribe. The well-known avidity with which pigs catch and eat rats explains the infection of swine, and it is from this source that man is infected.

Nearly all of the epidemics of trichinosis on record are confined to North Germany. In Saxony from 1860–75 there were 39 epidemics affecting 1,267 persons, of whom 19 died; at Hedersleben (1865), a town of about 2,000 inhabitants only, a total of 337 were sick and 101 died; at Emmersleben (1883) fully one-third died among those who ate the infected meat. Stiles has given a statistical review of trichinosis in Germany during recent years, from which is taken the following: 1860–1880—8,491 cases, 513 deaths, 6 per cent. mortality; 1881–1898—6,329 cases, 318 deaths, 5 per cent. mortality.

From the table of separate years it appears that there has been a general decrease in trichinosis in Germany during recent years, due probably to general education of the public on the dangers of eating raw pork as well as to meat inspection. The latter, which removes from consumption 1,500 to 2,000 trichinous hogs annually, is carried out in a most scientific manner by an army of some 30,000 inspectors and microscopists, at an annual cost (estimated) for the German Empire of $3,000,000, while for the city of Berlin alone the cost is $80,000. In spite of this system and expenditure security from trichinosis has not been attained *even for the meat examined*, as the following table shows, according to which more than half the cases of this disease are traceable to inspected meats.

During double the period given there have been recorded in the United States approximately 900 cases.

Of the 18 cases and 3 deaths alleged to have been due to American pork during 1881–83, neither Virchow nor others have accepted the evidence as tenable, and the careful examination made by Stiles renders it clear that the attacks upon American pork found in the German press are not supported by German health statistics. While the inspection doubtless diminishes chances of infection, it certainly gives rise to a false feeling of security.

Summary for the German Empire 1881–98 Inclusive.

	Cases.	Deaths.
Meat inspected and passed as free	2,042	112
Meat condemned but used	142	13
Due to defects in inspection system	1,204	7
Total results of errors	3,388	132
Inspection uncertain	63	0
No inspection of meat used	874	84
Data obscure or wanting	1,968	98
Said to be due to American meats	18	3
Due to uninspected Russian meat	18	1
	6,329	318

For the years 1860–95 Stiles has collected records of about 900 cases from the United States. Undoubtedly during this time cases have been diagnosed as atypical typhoid or rheumatism which were in reality attacks of trichinosis, but in the opinion of various authors there were also unrecorded cases in Germany. Nevertheless it is clear that there is a much less prevalence of the disease here, and it is interesting to note the nationality of these cases so far as recorded.

Table of Two Hundred and Seventy-Four American Cases.

	Cases.	Per cent.		Cases.	Per cent.
German	208	76.0	American	4	1.5
"Foreign"	37	13.0	French Canadian	3	1.0
Negro	10	3.0	"French descent"	1	.4
Italian	4	1.5	Dane	1	.4
Irish	4	1.5	Swede	1	.4

Statistics as to the prevalence of trichinosis are given by numerous European authorities from examinations made at autopsies. The results vary from nothing in France, according to Blanchard, to about two per cent. in Germany, according to various authors. These figures are based upon macroscopic examinations in large part at least, and Leuckart with others has remarked that greater success would follow more rigid search. In the United States Williams has subjected five hundred and five cadavers to a careful microscopical study, with the result that twenty-seven cases were found to be infected, or five and a third per cent. One-third of them were classed as severe, and only two were evident on examination with the naked eye. The nationality of the cases is given in the following table, which is suggestive, though the number is too small to warrant the drawing of final conclusions:

	Positive.	Negative.	Total.	Per cent. of positive cases in each nationality.
United States, white	6	201	207	2.89
United States, colored	5	65	70	7.14
British and Irish	5	57	62	8.06
Canadian	2	10	12	16.66
German	3	43	49	12.24
Italian		10	12	16.66
Other nationalities	0	27	27	0.00
Unknown	1	65	66	1.51
	27	478	505	5.34

The infection of rats varies so widely in different localities that little dependence can be placed on figures heretofore given from the examination of small numbers of individuals. The examination of pigs shows in Boston 4–5.7 per cent. infected (Billings), in United States army 2.1 per cent. (Müller), in various German districts from 1.5 per cent. to 0.1 per cent. The records of Mark show distinctly that reasonable hygienic conditions reduce the percentage of infection among pigs enormously, even in a few years.

The trichinæ are found most abundantly in the muscles of the diaphragm, tongue, and neck, and are present at times in incredible numbers, estimated by Leuckart at from thirty to forty millions for a single host (man). Diagnosis of the disease may be positively confirmed by the discovery of embryos in bits of muscle removed from the patient by scalpel or special harpoon.

The occurrence of other nematodes of somewhat similar size and appearance, the so-called false trichinæ, in the muscles and other organs of hare, rat, mouse, bird, fish, and even man (*cf.* case of Cobbold above, under *Leptodera terricola*) make it imperative that the determination be made with care in suspected cases of trichinosis. Of definite diagnostic value is the so-called "cell body" of the œsophagus, which is prominent in the anterior pointed region of the worm and which, though varying in length, is easily recognizable in all stages of growth and in both sexes (Fig. 3553).

Prophylaxis.—Man acquires the disease by the consumption of pork, in which are found living trichinæ. The chance of infection from all other animals is utterly inconsiderable, though a recent German author calls attention to the necessity of submitting dog meat to inspection on account of its rapidly increasing use as food. It has also been proved that salting, smoking, and other methods of curing ham do not afford a guarantee for the death of trichinæ which may be present. Two preventive methods have been suggested. The first is followed by Germany in her system of meat inspection; as already noted the system is expensive and does not afford absolute protection. Furthermore, unless the number of trichinæ present is enormous so that pathological changes have been induced in the flesh, the destruction of the meat constitutes an unnecessary loss of valuable food material. The second method of preventing the disease is the thorough cooking or curing of the meat so as to destroy the trichinæ. A temperature of 70° C. is sufficient to kill the encysted parasites, but in order that the centre of a piece of meat may reach this temperature cooking must be prolonged. One may determine the sufficiency of the cooking by the uniform clear gray color of a cut surface and the absence of red juice under pressure of the knife. This individual prophylaxis is both most reasonable and most effective; for the consumption of well-cooked pork is free from danger.

The old-fashioned slaughterhouse, at which the refuse was thrown to pigs and fell in part also to the rats infesting the place, was a serious menace to the health of the community, and offered the most admirable conditions for the rapid multiplication of parasites, especially these. On the other hand, the great modern packing establishments, in which all scraps are utilized under methods that destroy the life of any parasites present, are important agents in the limitation of this disease and in the general improvement of public health. Proper methods of slaughtering, curing, and preparing pork, and the abandonment of the unsanitary custom of eating the flesh of the pig uncooked are the true methods for the suppression of the disease.

Family of the Strongylidæ.—Body elongated, cylindrical, rarely filiform; alimentary canal complete; mouth provided with six papillæ, sometimes in the axis of the body, sometimes turned toward the dorsal or ventral surface, and frequently armed by chitinous teeth; œsophagus more or less enlarged at the posterior end, but not provided with a distinct bulb; sexes separate; male with caudal sac or bursa in shape like a saucer, or, if deeper, a bell encircling the end of the body. One or two spicules project from it, and the ribs or rays which mark its surface have characteristic arrangements in different species. The margin of this sac may be notched or deeply cut, so that it appears to consist of two separate parts; near the male orifice a small number of papillæ are often found. Female with one or two ovaries; female sexual opening very variable in position. The eggs when laid have undergone at least part of their development.

Strongylus apri (Gmelin 1789).—(Syn.: *Gordius pulmonalis apri* Ebel 1777; *Ascaris apri* Gmelin 1789; *Str. suis* Rud. 1809; *Str. paradoxus* Mehlis 1831; *Str. elongatus* Duj. 1845; *Str. longevaginatus* Dies. 1851; *Metastrongylus paradoxus* Molin 1860.)

Male, 12–25 mm. long, bursa bilobed, five ribs in each lobe, spicules very long and slender, measuring 2.5–4 mm. in length. Female, 20–50 mm. long, with short fish-hook tail at the base of which lies the anus and just in front of it the vulva on a rounded eminence. Eggs ellipsoid, 0.06–0.1 mm. long by 0.04–0.07 mm. broad; when laid they contain well-developed embryos.

The parasite inhabits commonly the bronchi and bronchioles of pig, sheep, and occasionally also man. Diesing reported it first from a six-year-old boy in Klausenburg; Chatin found some individuals, probably by accident, in the alimentary canal of a patient in France.

The observation of Rainey and Bristowe on nematode embryos from the larynx, which they called *Filaria trachealis*, points to this species even if an exact determination is impossible. Its abundant occurrence in the pig in Europe, and its extreme rarity in man point to some feature in the unknown life history, which renders human infection improbable.

Strongylus subtilis Looss 1895.—Body very slender and delicate, cuticula finely striated, oral papillæ inconspicuous; buccal cavity infundibuliform; œsophagus nearly one-sixth as long as the body. Male with inconspicuous alæ at anterior end, 4–5 mm. long, 90 μ in diameter at anterior end, 70 μ near bursa; two spicules, 0.15 mm. long, with accessory piece 0.05 mm. long (Fig. 3557). Bursa bilobed, with asymmetrical ribs. Female, 5.6–7 mm. long, 0.01 mm. in diameter at head, and 0.09 mm. in posterior third of body. Tail sharply pointed, anus near tip; vulva about one-fifth length from posterior end; uterus bilobed, with a few (three to six, or even eight or nine) eggs in each lobe; eggs oval, 63–70 by 41–36 μ, thin shelled, unsegmented, or partially segmented in uterus; development unknown.

Infection by drinking-water.

This parasite was described by Looss from specimens found at post-mortems in Egypt. It occurred in the stomach and duodenum of man and the camel. The infection was regularly light, and Looss doubtedits pathogenic character on account of this as well as its small size and unarmed buccal cavity. Later Ijima reported a record made by Ogata of the discovery as many as two hundred small nematodes in fluid taken from the stomach of a woman who died in Japan during the "Miura plague" of 1889. These parasites were identical with Looss' species, and while they were not regarded as the cause of the epidemic, it is clear that the presence of so large a number of parasites creates a presumption against their supposed harmlessness.

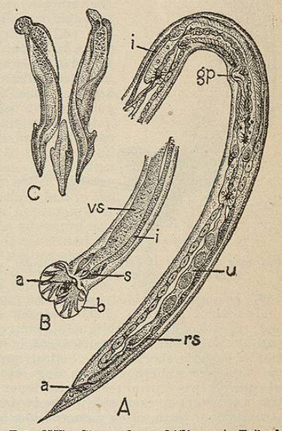

Fig. 3557.—*Strongylus subtilis*. *A*, Tail of female; *a*, anus; *gp*, genital pore; *i*, intestine; *rs*, seminal receptacle; *u*, uterus; *B*, tail of male; *b*, bursa; *s*, spicules; *vs*, seminal vesicle; *C*, spicules and accessory piece. Highly magnified. (After Looss.)

In view of its occurrence in such widely separated re-

gions, its discovery in intermedial territory is probable, and its introduction into the United States by travellers from the Orient or by returning American troops is an evident possibility under present circumstances.

Dioctophyme renale (Goeze 1782.) — (Syn.: *Ascaris canis* et *martis* Schrank 1788; *A. visceralis* et *renalis* Gmelin 1789; *Strongylus gigas* Rud. 1802; *Eustrongylus gigas* Diesing 1851; *Strongylus renalis* Moq.-Tand. 1860; *Fil. visceralis* Raill. 1885.)

Generally blood red, slightly tapering at both ends, especially the anterior; mouth triangular, bordered by six small papillæ. Male, 13–40 cm. long, 4–6 mm. broad. Caudal extremity obtuse, encircled by membranous pouch without rib lines, but with papillæ on margin. One slender spicule, 5–6 mm. long. Female, 20 cm. to 1 meter long; 5–12 mm. broad; tail obtuse and slightly curved; anus terminal; female sexual opening, 50–70 mm. from anterior end; eggs ovoid, thick-shelled, brown, 64–68 μ by 40–43 μ.

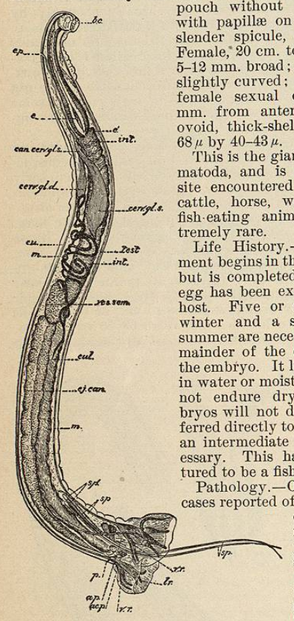

FIG. 3558.—Male of *Uncinaria duodenalis*. Magnified. (After Schulthess.)

This is the giant of all the nematoda, and is a kidney parasite encountered in man, dog, cattle, horse, wolf, and many fish-eating animals. It is extremely rare.

Life History.—The development begins in the female worm, but is completed only after the egg has been expelled from the host. Five or six months in winter and a shorter time in summer are necessary for the remainder of the development of the embryo. It lives a long time in water or moist earth, but cannot endure drying. The embryos will not develop if transferred directly to the dog, so that an intermediate host seems necessary. This has been conjectured to be a fish.

Pathology.—Of the numerous cases reported of the occurrence of this parasite in man, the majority are assignable to other parasites. Not more than ten are authentic. Trumbull's case (New York *Medical Record*, 1897) has been explained by Stiles as probably a *Filaria*.

Uncinaria Fröhlich 1789.—Anterior end curved dorsad; mouth opening obliquely from chitinous buccal capsule surrounded by transparent border; dorsal portion of capsule shorter than ventral, supported by conical structure sometimes projecting into cavity; at base of capsule two ventral teeth; near inner free border ventral wall bears on each side of the median line chitinous structures or teeth, often recurved like hooks (uncinate); inner dorsal wall also with teeth at times. Oviparous, eggs with thin transparent shell.

Of the species of this genus, which contains dangerous blood-sucking intestinal parasites of the higher mammals, two occur in man, one an Old-World species long known and the other recently discovered on this continent. In medical writings the worm is more ordinarily called *Anchylostoma*, and the disease which it produces is spoken of as anchylostomiasis. As the recent important contribution of Stiles, to whom I am also indebted for valuable personal communications, shows clearly, the name of one at least of the species in question here is that given above, and the term uncinariasis or uncinariosis should be adopted as the correct designation of the disease which is known also as brickmakers' and miners' anæmia,

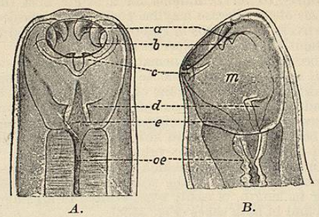

FIG. 3559.—Oral Capsule of *Uncinaria duodenalis* in (*A*) Dorsal and (*B*) Lateral Aspect. *a*, Inner; *b*, outer ventral tooth; *c*, dorsal tooth; *d*, stylet; *e*, dorsal rib; *m*, buccal cavity; *oe*, œsophagus. (After Hertwig.)

Egyptian chlorosis, tunnel disease, etc. Its chief symptoms are anæmia with the circulatory disturbances accompanying the pernicious type, colicky pains in the abdomen, great weakness, alternating constipation and diarrhœa with brownish or bloody stools, nausea, and œdema. Positive diagnosis is made by the discovery of the parasites and eggs in the fæces. In such cases care should be exercised not to confuse this with other species.

As the effects due to the two species are not distinguishable, a general discussion may be given for both together. By means of the powerful armature of the buccal capsule they pierce the intestinal mucosa and with the muscular œsophagus pump out blood. The intestinal epithelium is lost from the area taken into the capsule, and in addition to this the parasites move from spot to spot so that the host loses not only the blood taken by the parasite directly, but that lost through many minute hemorrhages at previous points of attack. The functional vitality of the intestinal wall is evidently reduced, and some are inclined to believe that the parasite also produces a poison which acts upon the host unfavorably.

Thymol and male fern are most frequently used for driving out these parasites, and Stiles quotes the following directions for thymol treatment:

Two grams of thymol at 8 A.M., repeated at 10 A.M., and castor oil or magnesia at noon. Diet of milk and soup. As some cases are obstinate, a re-examination of the fæces in a week is necessary, and the repetition of the treatment if eggs are still to be found. It should be noted that on the whole experiments are very unfavorable to the use of alcohol during the thymol treatment.

Rational prophylaxis must be based on better knowledge of the extent of the disease. When it is suspected microscopical examination of the fæces and treatment of all infected individuals are necessary preliminaries to its eradication. The construction of water-tight latrines in tunnels, brickyards, and other corporation properties where the disease is prevalent, together with the periodic disinfection of their contents by quicklime or by cremation, will largely prevent the spread of the disease. If, in addition, defecation in other places is forbidden and the regulation enforced, while on the other hand fresh pure drinking-water is supplied and workmen are impressed with the necessity of personal cleanliness as a preventive for the disease,

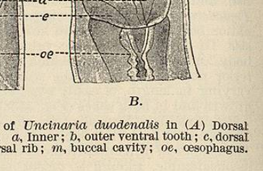

FIG. 3560. — Bursa of Male *Uncinaria duodenalis*. Magnified. (After Railliet.)

the difficulty will be reduced to a minimum. It must be kept in mind that Looss has demonstrated the probability of infection from water with larvæ coming on to the skin, so that the presence of such larvæ in standing water is a real menace, even if none of it ever reaches the mouth.

The Old-World species has been known for some time, and its effects are clearly traceable back of the historic study of Perroncito, which showed it to be the cause of the severe miners' anæmia, which was associated with the construction of the Saint Gothard tunnel. It is only within the year 1902 that Stiles has called attention to the tremendous economic and hygienic importance of the New-World species in our Southern States, although the records of the presence of some species, probably this one, extend back for many years. In Central America uncinariasis has been for centuries the most important and dangerous general disease, involving twenty-three per cent. of the population; it appears in the old Indian traditions, and with the disease is associated "dirt-eating." The species has not been precisely determined. In Africa the infected negro does not seem to be subject to any resulting anæmia.

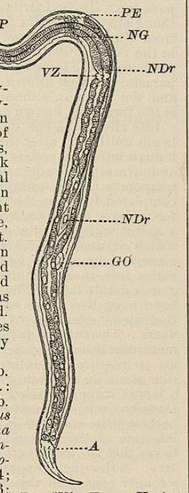

FIG. 3561.—Young *Uncinaria duodenalis* Four Days After Infection. *A*, Anus; *GO*, genital cell; *NDr*, œsophageal glands; *MH*, oral cavity. × 190. (After Looss.)

Uncinaria duodenalis (Dub. 1843) Railliet 1885. — (Syn.: *Agchylostoma duodenale* Dub. 1843; *Strongylus quadridentatus* v. Sieb. 1851; *Anchylostoma duod.* Dub. 1850; *Dochmius anchylostomum* Molin 1860; *Sclerostoma duodenale* Cobbold 1864; *Str. duodenalis* Schn. 1866; *Dochmius duodenalis* Leuck. 1876; *Ankylostoma* and *Ankylostomum duod.* auct.)

Body cylindrical; buccal cavity with two pairs of uncinate ventral teeth, and one pair of dorsal teeth, directed forward; dorsal rib not projecting into capsule. Female, 10–18 mm. long by 0.5–0.6 mm. wide; vulva at or near posterior third of body; eggs 52 by 32 μ, segmenting when deposited with direct development. Male (Fig. 3558), 8–11 mm. long by 0.4–0.5 mm. wide; caudal bursa (Fig. 3560) with dorso-medial lobe, dividing at two-thirds the distance from base, each branch being tridigitate, and with prominent lateral lobes united by a ventral lobe; spicules long, slender.

This species occurs in the upper region of the small intestine of man, and has been reported from Europe, Africa, Asia, the Philippines, and recently also from North America and the West Indies, where some regard it as of very recent introduction. A number of cases, including one fatal one, are on record in the United States within two years.

Structure.—One point in the structure deserves special attention—the so-called pharynx or buccal capsule (Fig. 3559). This is very nearly spherical, and is armed with four strong curved chitinous teeth. At the bottom of the capsule are two triangular lance-like organs, the function of which is the penetration of the tissue of the host. The body is curved dorsad at the anterior end on account of the shortness of the dorsal wall of the buccal capsule, so that the orifice actually points dorsad.

Life History.—The eggs are deposited in the alimentary canal of the host and must pass out of the body in order to undergo development, which will not take place in water, but proceeds rapidly in fæces or in slime, so that the rhabditiform embryo is hatched in twenty-four hours at 27° C. As 1° C. kills the eggs in from twenty-four to forty-eight hours, the climate of a large part of this country is an evident barrier to the spread of the parasite. At hatching the embryo measures 0.3 mm. in length, but grows rapidly, and after moulting once it enters upon a resting stage within the cast-off skin of the second moult. In this, the infecting stage of the parasite, the worms may live for a month or more in water without food, but if subjected to desiccation they perish. This naturally points to water as the probable means of infection, although the presence of such larvæ on moist salads and other vegetables, eaten uncooked, may well be a subsidiary means.

Recently Looss has brought forward the idea that these larvæ may enter the human body by way of the skin, which stands in perfect agreement with his earlier observations, that the larvæ which were fed to various animals in water did not settle down but were discharged per anum unchanged; yet part of them bored into the mucosa of the larynx and œsophagus and were active and growing two weeks later. When taken into the human body the worms undergo radical changes in structure. One may distinguish with Looss a third stage without buccal capsule (Fig. 3561), a fourth with provisional buccal capsule (Fig. 3562), and a fifth in which this organ corresponds to the adult form. From four to six weeks from the time of infection are required for the parasites to mature.

The view of Looss, that infection may take place through the skin, has been confirmed by a number of observations and experiments. Most striking was the infection of a limb about to be amputated and the subsequent discovery of many larvæ, which had forced a way in between hair and follicle and appeared in sections to have penetrated as far as the subdermal tissue. This method of infection, which Looss believes to be the most extensive, explains the susceptibility of Egyptian field laborers, and also epidemics among brickmakers as well as all cases in which the workmen are wont to work in moist earth with bare feet and hands. It explains the infection of children walking on damp ground, and gives, according to Bentley, the key to the "ground itch," or Pani-ghao, an affection of the skin of the lower extremities, endemic in Assam and in the West Indies. Its appearance is coincident with the advent of the rainy season, and is associated by this author with the presence of the larvæ of *Uncinaria duodenalis* in the soil of the infected areas. The typical lesion consists in a primary erythema followed by a vesicular eruption, which frequently becomes pustular, and in severe cases may result in obstinate ulceration or even in gangrene.

FIG. 3562.—*Uncinaria duodenalis* in Stage II. of Development. × 105 (After Looss.)

Uncinaria americana Stiles 1902.—Ventral recurved uncinate teeth absent from mouth, one pair prominent dorsal semilunar plates, and an inconspicuous ventral pair being present; dorsal median conical tooth projecting prominently into buccal capsule (Fig. 3565). Female, 9–11 mm. long by 0.31–0.35 mm. wide; vulva near middle of body but in front of it; eggs (Fig. 3564) 64–72 μ by 36–40 μ, segmenting or with well-developed embryos when deposited. Male, 7–9 mm. long by 0.29–0.31 mm. wide; dorsal ray of caudal bursa divided to the base, each