The female deposits eggs in the galleries of the mucosa, which give rise to embryos that wander out into the lumen of the intestine. In Teissier's case it was claimed that these embryos had taken a different route and had entered the circulation, perhaps by way of the chyle tubes; their presence here was accompanied by high temperature, which abated with their disappearance three days later. More probably this case represents a double infection of *Filaria* with *Strongyloides*. The limited number of *Strongyloides* eggs found in the fæces is to be explained perhaps on their deposition deep in the tissue. More recently Strong has confirmed the presence of adults, eggs and embryos in the epithelium and in the cavity of the crypts of Lieberkühn, in which cases the epithelium is often atrophied and less frequently entirely gone. Infiltrations of small round cells were observed in some cases, but no marked inflammatory changes. This author believes that the parasite is not harmless, though not particularly dangerous; and he finds it capable of producing an intermittent diarrhœa with intestinal disturbances. It certainly causes some mechanical injury from its rapid movements.

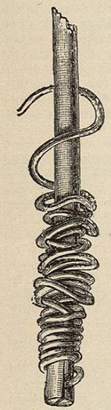

FIG. 3542.—*Filaria medinensis*, Rolled on Split Stick. (After Fedtschenko.)

Prevention.—The use of filtered or boiled water and abstinence from eating uncooked vegetables of any sort, as well as the destruction of stools from patients afflicted with the parasite, are evident measures suggested by the life history. Special mention has been made by various observers of the general immunity of natives in Cochin China toward both the parasites and the endemic dysentery, and it has been explained on the basis of their universal use of water boiled or treated with alum sufficient to precipitate the organic matter.

The hydrotactic tendency of the embryos is useful in diagnosis in cases in which they are present in small numbers, since in the centre of a fecal layer spread on a culture plate a small cavity can be made and filled with water; here the embryos collect and are easily found. In pure water the embryos of the free generation are apt to perish, perhaps through lack of food materials. Leichtenstern has also pointed out that a differential diagnosis between this species and *Uncinaria* is not difficult, since in fresh fæces the latter form appears only as eggs, the former only as embryos. The *Uncinaria* embryo is also easily distinguished from that of *Strongyloides*, since the latter has a short thin-walled oral cavity, hardly chitinized at all, and a large spindle-shaped sexual rudiment, 33 μ long, while the former possesses a long, heavily chitinized oral cavity and a minute circular sexual rudiment, only 3 μ long. If eggs are taken from the canal at a necropsy, those of *Uncinaria* are distinguishable from those of *Strongyloides* by the smaller size and thicker shell.

Treatment.—Turpentine and male fern have no apparent effect. In mild cases thymol with general tonic treatment is successful generally, but in severe infections nothing yet reported is of any apparent value.

A genus which offers evident affinities to both Strongylidæ and Filaridæ, but which is usually included in a separate family, the Gnathostomidæ, is represented among human parasites by a single rare species:

Gnathostoma siamense (Levinsen 1889.)—(Syn.: *Cheiracanthus siamensis* Lev. 1889.)

The genus is easily recognizable by the numerous spines which cover the entire body, or at least the anterior region. Several species occur in the Felidæ, and in swine and cattle. This form is known only by a single female specimen, length 9 mm., breadth 1 mm.; about the head eight circles of spines. The anterior third of the body alone is covered with spines, the anterior of which are three-pointed, and the posterior simple. The vulva lies behind the centre of the body.

The specimen was collected in Siam and came from a small tumor; when this disappeared there were found on the skin nodules the size of a pea, from one of which this worm emerged. The same symptoms were observed in two other cases, and in one of these five or six worms were expelled, but were not preserved.

Family of the Filaridæ.—Body greatly elongated, filiform; mouth variable, often papillate, sometimes with lips and even with a buccal capsule; œsophagus slender and without a bulb; male, with somewhat coiled tail and a single spicule or two unequal ones. Female, with double ovary and vulva near the anterior end of the body. Many species are ovoviviparous.

Filaria O. F. Müller 1787.—Very slender worms of nearly equal calibre throughout. Males notably smaller than the females, with coiled posterior end, which possesses in some cases alar appendages. Spicules ordinarily very different in size and form. Four preanal papillæ are almost constant; the number of postanal papillæ is, however, variable. Vulva always near the anterior end.

These forms are parasites of the serous cavities and subdermal connective tissue; in general the development, though not well known, appears to be indirect with an intermediate host from Crustacea or Insecta. Raillet justly remarks that for the physician this genus is a sort of "catchall" into which he throws all round worms, old or new, of which the structure is poorly known.

Filaria medinensis (Linnæus 1758)—(Syn.: *Gordius medinensis* Linn. 1758; *F. medinensis* Gmelin 1789; *F. dracunculus* Bremser 1819; *F. æthiopica* Valenciennes 1856; *Dracunculus medinensis* Cobbold 1864.)

Female: 30–100 cm. long (ordinarily 50–80), 0.5–2 mm. broad; body uniform in diameter, white or yellowish-brown; the anterior end smooth, rounded, with cephalic shield, and small mouth surrounded by six papillæ; alimentary canal atrophied in adult and with all other internal organs replaced by enormously developed uterus; vagina has disappeared. Uterus filled with larval filariæ, 0.5–0.75 mm. long and 15–25 μ wide.

Male doubtfully observed, said to be much smaller than female, only 4–10 cm. long, found fixed to the female by its posterior extremity, about 14 cm. from the anterior end of the latter. If the observation is substantiated, the male follows the female into the tissues and perishes soon after copulation there. The vagina atrophies subsequently to this.

The so-called "guinea-worm" is the subject of the oldest records dealing with any parasite. Doubtless the fiery serpents which plagued the children of Israel in the wilderness were this species. The writings of the Egyptians and those of early classical times, as well as later authorities, make definite references to it. The Arabian physicians knew it well, and Rufus, of Ephesus, not only gives a good description of the disease and its cause, which he designates as a little snake, but recounts the commonly accepted opinion that "the Arabians suffer from it, and many strangers acquire the disease *if they drink the water*, for that is the chief cause."

Life History.—The adult female is met with in the connective tissue, particularly of the legs and feet. It appears here in eighty-five per cent. of all cases, and pierces the derma; a blister forms in the epidermis over this orifice, and on rupturing shows a small ulcer at the centre of which is a minute opening. If cold water is dashed on the surface here, a drop of a milky fluid exudes or a small tube (the uterus?) is protruded and bursts, setting free the opaque fluid. This fluid contains multitudes of embryos 0.5–0.75 mm. long and 15–25 μ wide; they are flattened, terminate in a long pointed tail, and have a striated cuticula and a complete alimentary canal. They swim actively but intermittently, and live six days in pure water, but from two to three weeks in muddy water or moist earth.

As may be followed experimentally they enter the body cavity of small aquatic animals (*Cyclops*, Fig. 3543) through the joints in the exoskeleton, and there with two or three moults, occupying five or six weeks, they metamorphose into a more cylindrical form with a tripartite posterior end. The further life history is unknown. Fedtschenko tried to infect cats and dogs with these infested *Cyclops*, but without result. Manson and Blanchard have successfully repeated these experiments. Some further changes may easily be necessary before the parasite is fitted for its final host, which may be cattle, horse, dog, wildcat, or jackal as well as man.

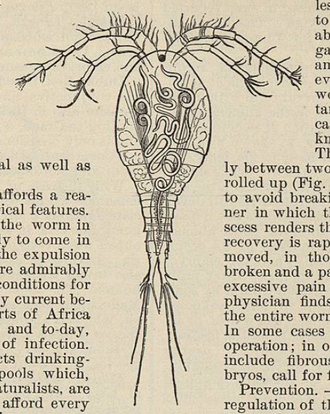

FIG. 3543.—Embryos of *Filaria medinensis* in body cavity of *Cyclops*. (After Fedtschenko.)

The life history, as given above, affords a reasonable explanation of some biological features. Both the preferential location of the worm in legs and feet which are most likely to come in contact with standing water and the expulsion of the embryos on such contact are admirably adjusted to secure for the young conditions for further development. It is a widely current belief among natives in different parts of Africa and Arabia, both in ancient times and to-day, that drinking-water is the source of infection. In the majority of infected districts drinking-water is obtained from surface pools which, according to the observations of naturalists, are swarming with *Cyclops*, and hence afford every opportunity for the spread of the disease.

Distribution. — The guinea-worm is rather widely distributed in tropical and subtropical countries. Most abundant in Deccan (India) and on the west coast of Africa, where in some seasons from one-half to nearly the entire population is affected, it is found more or less from India westward through Southern Asia and tropical Africa, and in a limited area of Brazil, where its introduction may probably be attributed to the slave trade. In Curaçoa and Surinam, where it was formerly endemic, and where it was no doubt introduced with negroes, it has now entirely disappeared. Records of its occurrence in Europe and North America are from natives of the infected area or visitors to it, and though frequently introduced it has never gained a footing in either place. Records of its occurrence in Africa and Arabia are found in historical and medical works of all ages. It is also known to occur in Persia, Turkestan, and Hindustan.

Pathology.—The seat of the adult females is the subcutaneous connective tissue, and they occur most commonly in the lower extremities, especially in the foot and ankle, but have been found in the arm, tongue, eyelid, scrotum, perineum, and trunk. As many as five or six in a single host is not uncommon. The presence of the worm is not detected ordinarily until it approaches the skin, where it produces a swelling, at first painless but later painful, and ultimately a running sore. Of itself the worm may be considered comparatively harmless, but the complications incident to a tropical climate often bring about excessive suppuration and gangrene, such as to necessitate amputation of the part infected, or even to be followed by death. The worm is sometimes expelled spontaneously, but in the majority of cases it is extracted by what is known as the Soudanese method. The end of the worm is seized firmly between two splints, on which it is gradually rolled up (Fig. 3542), great care being exercised to avoid breaking the slender body. The manner in which the worm is coiled up in the abscess renders the operation very slow, and while recovery is rapid when the entire worm is removed, in those cases in which it has been broken and a part left behind, the result has been excessive pain and often fatal gangrene. The physician finds it more satisfactory to remove the entire worm at once by a simple operation. In some cases complete cure follows a single operation; in others subsequent growths, which include fibrous tissue with numbers of embryos, call for further operative interference.

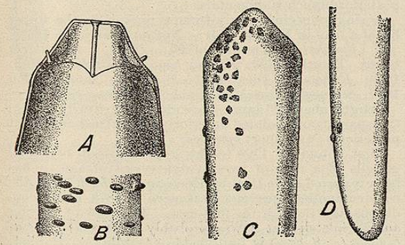

FIG. 3544.—*Filaria loa*. *A*, Head of male; *B*, mid body of male with cuticular bosses; *C*, head of female with bosses; *D*, posterior end of female with two bosses. Magnified. (After Blanchard.)

Prevention. — Apparently the satisfactory regulation of the supply of drinking-water will prove the means of stamping out the disease. Surface water is particularly suspicious on account of the large number of *Cyclops* likely to be present.

Filaria loa Guyot 1778.—(Syn.: *F. oculi* Gerv. et v. Ben. 1859 (nec. v. Nordm. 1852); *Dracunculus oculi* Diesing 1860; *Dr. loa* Cobbold 1864.)

Female 30–40 (rarely 70) mm. long, by 0.5 mm. broad, of cylindrical form (Fig. 3544) with anterior end blunt, posterior, straight, pointed; cuticula, transparent, yellowish, not striated but marked with minute, chitinous bosses irregularly distributed; uterus bifid, coiled; eggs 30–35 by 20–25 μ; when deposited containing embryos 210–250 μ in length.

Male: 20–30 mm. long, 0.3–0.45 broad; cuticula not striated, but with small papillæ except on first and last fifth; mouth without papillæ; tail (Fig. 3545) slightly incurved, with lateral wings and five ventral papillæ on each side, three being preanal and the first the largest; spicules two, short, unequal.

It was first observed in 1770, though a print of 1597 seems to show an operation for its removal. Nearly thirty cases are now on record; most of these are only notes, but recent descriptions of Ludwig and Blanchard have made its appearance and structure known. The earlier authors were inclined to regard it as identical with *F. medinensis*, but its specific distinctness maintained by others is now clearly demonstrated. Even if the immaturity of specimens eliminates the difference in size, the smooth striated cuticula of the guinea-worm will serve to separate it at once on careful examination from *F. loa* with its non-striated, embossed surface. The embryos differ also.

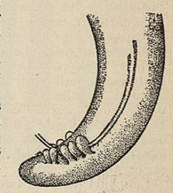

FIG. 3545. — Tail of Male *Filaria loa* with Spicules and Papillæ. (Author's specimen.)

In distribution *F. loa* is limited to an area on the west coast of Africa (Guinea, Gold Coast, Gaboon), where it is not uncommon, and cases reported from other regions, which are largely among slaves of earlier days, have been those of persons who had come more or less recently from that region. Such are on rec-

ord from Brazil, Trinidad, St. Domingo, France, England, and the United States.

Naturally the majority of records affect negroes, but physicians in Africa maintain that the parasite attacks blacks and whites alike, and the number of cases reported among missionaries supports this view. One of the latter has recently been reported in the United States by Ward and Milroy.

Life History.—From the scattered facts on record Blanchard has outlined the course of development as follows: Introduced into man in the larval form with drinking-water, the form becomes adult in the alimentary canal. Either before or after copulation it penetrates the tissues where its development is slow, as shown by a residence of from four to ten years or more in the body. It appears beneath the conjunctiva of the eye or the skin at the last phase of its existence, but it may reach the surface of the body without having acquired its full development. That unlike *F. medinensis* it does not deposit eggs in dermal abscesses is clear from the entire absence of pus formation and of eruption in cases of its occurrence. It is a prisoner in the body, and the embryos must escape independently of the mother. They probably penetrate the blood, and are drawn from it by some blood-sucking parasite, from which in some unknown way they reach running water and in it a new host, or are inoculated directly when the intermediate host is feeding. Manson has conjectured that the well-known *F. diurna* is the larva of *F. loa*, with which it agrees in geographical distribution. The opinion is generally accepted among inhabitants of the affected region that the source of infection is to be found in drinking-water.

Pathology.—The parasite is an active migrant through the connective tissue, but comes often into the region of the orbit. Its appearance in the tissue of the lid or beneath the conjunctiva is made known ordinarily by itching or even by slight pain which may disappear with the withdrawal of the worm, only to recur with its subsequent return at irregular intervals of days, weeks, or even months. An individual has been seen to pass rapidly from the one eye to the other over the bridge of the nose. In one case only has an immature specimen been found actually within the eye. In addition to itching, transient œdematous swellings accompany its appearance in various parts of the body. Fugitive tumefactions, known as Calabar swellings, are not uncommon in lower Nigeria. They are half the size of a goose egg, painless, sudden in appearance, disappearance, and recurrence, and may be found in any part of the body. They are thought to be produced by rubbing when a *F. loa* approaches the surface.

Treatment.—The negroes drive it from the eye by dropping a grain of salt into the conjunctival sac or by extracting the worm with a thorn. Deftness in operating is necessary, and if after cocainizing the eye the worm be grasped with a pair of forceps, a cut in conjunctiva or lid gives an opening through which it usually starts to escape, or may be withdrawn by a second forceps.

Filaria volvulus Leuckart 1893.—Body tapering uniformly, head rounded. Male 30–35 cm. long, 40–140 μ in diameter, tail incurved; one postanal, two adanal, one preanal papilla on each side, two spicules 0.08 and 0.177 mm. long. Female 40–70 cm. in length. Embryos 250 μ long, 5–6 μ wide, resembling *F. nocturna* and *F. diurna*, but shorter and thicker and without sheath, head rounded, tail very sharp, clear spot in anterior fourth of body.

Leuckart received two dermal tumors from Gold Coast negroes containing several worms coiled in a ball and surrounded by a fluid containing embryos. A somewhat similar tumor excised from the arm of a French soldier, who had been in Dahomey, showed that the worm occupied a lymph vessel and was surrounded by a mass of connective tissue. Its identification as the same species has been questioned. Prout has recently described two other cases from Sierra Leone. Like *F. loa*, it is viviparous and found in subdermal tissue; but unlike that species it is sedentary and produces a circumscribed subcutaneous tumor.

F. conjunctivæ Addario 1885.—(Syn.: *F. palpebralis* Pace 1867, nec Wilson 1844; *F. peritonei hominis* Babesiu 1880; *Filaria inermis* Grassi 1887.)

Female: Length 10–16 cm., width 0.5 mm.; cuticula striated not embossed or papillate; mouth terminal, unarmed, vulva near anterior end; uterus double, with eggs and embryos measuring 350 by 5.5 μ. Male unknown.

Dubini first found this species in Sicily in a tumor of the conjunctiva, and it has been recorded as a human parasite also in Italy and Hungary. The species is, according to Grassi, a normal parasite of the horse and ass, and is only occasional in man.

Filaria lentis Diesing 1851.—(Syn.: *Filaria oculi humani* von Nordmann 1832.)

With the case of von Nordmann, in which immature nematode worms were found in the lens, have been associated various poorly known and often doubtful cases of later observers, in several of which it is probable that the object was a vestige of a vessel or filament and not a filaria. In three cases the parasite was in the lens, in three also in the vitreous humor, and in two in the aqueous humor. The most recent, by Drake and Brockman, at Madras, has been assigned by Blanchard to *Filaria equina*, which is abundant in India. The character of other species is likely to remain permanently doubtful. Some of them are very likely young forms of the preceding species, *F. inermis*.

Filaria restiformis Leidy 1880. Length 66 cm., width at head 0.375 mm., at centre 1.5 mm.; anterior end pointed, posterior blunt; mouth without papillæ; œsophagus 1.125 mm. long.

Passed in West Virginia from the bladder of a man, fifty years of age. The patient had been suffering some days from hæmaturia. Railliet regards it as evidently a pseudoparasite. While it was not extracted by the attending physician, he maintained that no doubt existed as to the correctness of the patient's statements that the worm had actually been passed.

Filaria hominis oris Leidy 1850.—Length 14 cm., width at head 0.1 mm., at centre 0.38 mm. Mouth terminal, posterior end provided with an epidermal spine, 0.05 mm. long.

Leidy found the single specimen in the collection of the Philadelphia Academy labelled, "Obtained from the mouth of a child," and queried if it might be the young or the male of *F. medinensis*. Leuckart shared the opinion which has, however, been questioned by some later investigators.

F. labialis Pane 1864.—Length 30 mm.; pointed anteriorly; mouth with four papillæ, posterior end slightly inflated; vulva in posterior tenth; uterus double, but in posterior branch rudimentary.

A single specimen only from a pustule on the upper lip of a man in Naples, Italy. Not reported since 1864.

F. lymphatica Treutler 1793.—(Syn.: *Hamularia lymph.* Treutler 1793; *Filaria hominis bronchialis* Rud. 1819; *F. hominis* Dies. 1851; *F. lymph.* Moq.-Tandon 1860; *Strongylus bronchialis* Cobbold 1879.)

Length about 26 mm.; brownish spotted with white; transparent and pointed anteriorly; thickened and blunt posteriorly; two short spicules.

First found in 1790 in the hypertrophied bronchial ganglia of a man of twenty-eight years of age; it has been reported since then by Brera and by Zürn, who discovered another specimen at Geneva in 1879, under conditions like those of the first case. The view of Diesing and Weinland, that it was probably *Strongylus longevaginatus* (= *S. apri*) is improbable according to Railliet, who views it as a male of *F. inermis*. The view of Braun that it is *F. equina*, a common parasite of horse and ass in Europe, seems more probable.

Filaria immitis Leidy 1856.—Mouth with six papillæ. Male: 12–18 cm. long, 0.7–0.9 mm. wide; posterior end with low lateral wings and eight preanal as well as nine to ten postanal papillæ; posterior end rolled in several turns like a corkscrew, spicules unlike. Female: 25–30 cm. long, 1–1.3 mm. wide, posterior end shortly blunt; vulva in posterior fourth; ovoviviparous embryos 0.28–0.30 mm. long and 5 μ wide, with a greatly attenuated posterior extremity.

Originally found by Leidy in the heart of a dog, it is now known to inhabit the entire venous system. The

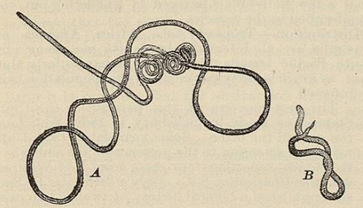

FIG. 3546.—*Filaria Bancrofti*. *A*, Adult male × 7.5. *B*, Embryo from hydrocele fluid × 200. (After Lothrop and Pratt.)

embryos are to be found in the peripheral circulation during the period of rest. With growth they retire to the larger vessels and escape from the kidneys or in excrement. Their normal method of exit is unknown. The parasite is most common in dogs living in the open.

The parasite is common in the United States, especially in the South and in South America. It seems to be very abundant in China and Japan, and is reported also from Italy, France, Germany, and Denmark.

As Moniez has shown, Braun was apparently in error in citing Bowlby as authority for the occurrence of this species in man; and Braun's own case is too uncertain in determination to be accepted as evidence in absence of other instances. If *F. immitis* is even occasionally a human parasite, it should be found as such in the United States, where it occurs commonly. No case has been found on record.

Filaria Bancrofti Cobbold 1877.—(Syn.: *Trichina cystica* Salisbury 1868, non Filaria cystica Rud. 1819; *F. sanguinis hominis* Lewis 1872; *F. sang.-hom. ægypt.* Sonsino 1874; *F. dermathemica* Da Silva Araujo; *F. Wuchereri* da Silva Lima 1877; *F. sanguinis hominis nocturna* Manson 1891; *F. nocturna* Manson 1891.)

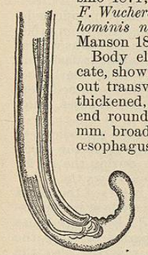

FIG. 3547.—Tail of Male *Filaria Bancrofti*. Magnified. (After von Linstow.)

Body elongated, white, opaque, very delicate, showing tendency to coil; cuticula without transverse striation, anterior end slightly thickened, without lips or papillæ, posterior end rounded. Male 35–40 mm. long; 0.1–0.12 mm. broad, head 51 μ, neck 43 μ, in diameter; œsophagus 0.13 mm. long; tail (Fig. 3547) slightly bent, 1 mm. long; papillæ undescribed; spicula 0.2 and 0.6 mm. long. Female 75–95 mm. long, 0.21–0.28 mm. broad, head 68 μ, neck 51 μ in diameter, vulva 0.72–1.27 mm. from head, anus 0.282 from tail. Eggs 25–28 μ or 35 (Lothrop and Pratt) by 15 μ. Embryos 0.127–0.2 mm. (or 0.2–0.33 mm.) long by 8–10 (7–11) μ broad, with unstriated cuticula, but enveloped in a delicate sheath (Fig. 3546, *B*).

Although first reported as early as 1863 by Demarquay, this form has been very generally confused with other species of the group, especially *F. Magalhaesi*, and even now only a little can be given beyond the data contained in the general characteristics which are taken from Maitland and Manson's account, and from that of Lothrop and Pratt. The discrepant measurements given by different authors are due, in part at least, to the fact that different species were under consideration.

The male (Fig. 3546, *A*) is much shorter than the female, and the posterior end exhibits a strong tendency to twist like a tendril. Both sexes manifest a proclivity to curl into a knot, and various observers note the difficulty of disentangling the individual worms from such a mass. In the female, which alone has been examined, the anterior end is traversed by four deep grooves, giving the transsection much the form of a maltese cross. The thick-walled vagina extends posteriorly a short distance from its external orifice, and splits into two thin-walled uterine tubes, which occupy the entire cavity of the body, forcing the intestine against the muscular wall at one side. These tubes are filled with ova and embryos in all stages of development. The smaller embryos are coiled within a thin structureless chorion. Preserved specimens may assume a brownish tint, owing to a change in the color of the uterine walls.

The embryonic filariæ in freshly drawn blood or in hydrocele fluid are rounded at the anterior end and pointed at the posterior. Though in constant motion, twisting and coiling, they never (?) exhibit a true progressive movement. In freshly drawn blood they are covered by a delicate sheath, which is indistinguishable normally except as a flagellum following the tail at some distance, 0.3–0.4 mm. (Fig. 3548); rarely, when the movement of the body is reversed, this disappears from the tail and becomes evident at the head (Fig. 3548, *A*). It is evidently the collapsed sheath, which Manson regards as a vitelline membrane, and in such specimens as have undergone endosmotic changes it appears like a distended sac enveloping the entire worm; such an appearance, though frequently figured, is entirely unnatural. The embryos of other species, *e.g.*, *F. immitis*, are without this sheath. These embryos may be kept alive five or more days in a cover-glass culture of blood, and after forty-eight hours many empty sheaths may be observed. Attached to the tip of the head is a minute spine, which at times is protruded in rapid succession with a peculiar "pouting" movement.

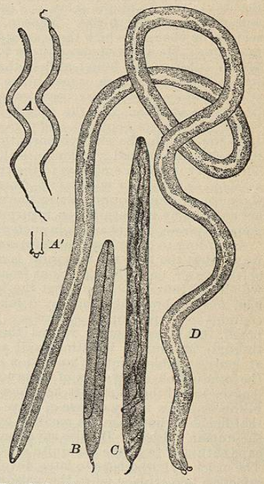

FIG. 3548.—Metamorphosis of *Filaria Bancrofti* in Thorax of Mosquito. *A*, Just ingested; *A'*, posterior end; *B*, five days old; *C*, ten days old; *D*, sixteen days old. (After T. L. Bancroft, except *A'* after Manson.)

Life History.—The female is viviparous, and the embryos, which are produced in enormous numbers, are evacuated into the lymph stream and ultimately pass from it into the blood current, where they are often found in extraordinary abundance. They measure 0.2–0.33 mm. by 7–11 μ (Lothrop and Pratt, 0.26–0.3 mm. by 6–8 μ). Twelve hours after being taken into the stomach of a mosquito one finds side by side free embryos and empty sheaths. By the next day the embryos have traversed the wall of the stomach and are in the thoracic muscle. At the end of eleven days they are 20–25 μ broad and more than 580 μ long. At seventeen to eighteen days they begin to leave the muscles and migrate into connective tissue in front of the prothorax. Such larvæ are

more slender than before, 18–20 μ in diameter. These larvæ show an alimentary canal with œsophagus well differentiated and rudiments of the reproductive apparatus. While some remain in muscles even up to the fif-

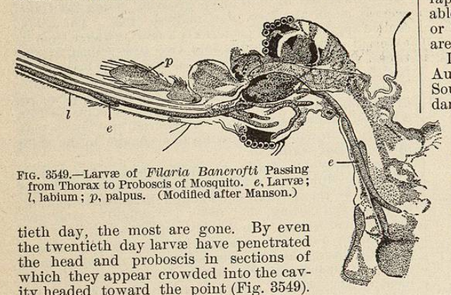

FIG. 3549.—Larvæ of *Filaria Bancrofti* Passing from Thorax to Proboscis of Mosquito. *e*, Larvæ; *l*, labium; *p*, palpus. (Modified after Manson.)

tieth day, the most are gone. By even the twentieth day larvæ have penetrated the head and proboscis in sections of which they appear crowded into the cavity headed toward the point (Fig. 3549). Like the malarial organism they are inoculated directly. The last stage of development occurs in the skin; they become adult and copulate there; thus the variable position of lesions of elephantiasis are explained. In *Anopheles* James finds that the transformation requires only from twelve to fourteen days, and the activity of the embryos does not cease. According to the same author the broad inactive form measures 71–53 μ long and the slender active form 151–132 μ long and 2.6 μ broad; in this latter stage the œsophagus is two-fifths and the tail one-third of the entire length.

Bancroft and Manson suggested almost simultaneously that the mosquito might serve as a carrier of the embryonic filariæ in the blood. Manson, however, first observed the changes which these embryos undergo in the mosquito. He allowed mosquitoes to suck the blood of filarial subject, and found at first that the embryos are within a delicate sheath or membrane, apparently almost structureless; later, there becomes evident a marked transverse striation, and the sheath is ruptured by the worm forcing its cephalic end against it. Once free from the sheath, the embryo bores through the stomach wall of the insect and wanders into the thoracic muscles. The embryos which emigrate to the thoracic cavity do so as soon as they are withdrawn from the human host; those found some hours later in the mosquito's stomach are such as by immaturity or injury are not destined to metamorphose, and changes in such are retrogressive.

According to one view the worm escapes by boring its way out at the time the mosquito is depositing her eggs on the water, or by breaking out from dying mosquitoes which fall into a pool, and that the infection of the human host is brought about by drinking such water as contains well-developed embryos. It is further supposed that these young worms then bore their way through the human intestinal wall and attain maturity at some suitable point. Copulation here is followed by the production of swarms of embryos. In objection it may be urged that Bancroft has shown water to be fatal to the embryos in the course of three or four hours, and that hence it cannot be the medium by which they reach the human subject. He also says the embryos never escape naturally from the mosquito's body even if in water. The other hypothesis as to later development is that the infection takes place when the mosquito containing the fully developed embryos is sucking blood, and Bancroft has proved the migration of such embryos from the thoracic muscles into the labium, from which he believes they escape at a definite point at the tip to penetrate the body of the new host. Grassi believes that the larvæ escape from the bent labium in the act of biting by rupture of the cuticula. This part of the life history has not been cleared up as yet.

In the transmission of embryos certain species of mosquito only are culpable; among such are *Culex fatigans* in Australia, *Anopheles Rossii* in India, probably also *Anopheles musivus*; this genus James regards as the proper intermediate host, since in it the development is more rapid. In case the embryos are taken up by any unsuitable species of mosquito they are digested in the stomach; or if a few individuals succeed in wandering out, they are absorbed in the muscles.

Distribution.—Tropical Asia, Africa, America, and Australia are all infected. In Samoa and some other South Pacific Islands this parasite is particularly abundant, as much as fifty per cent. of the population being infected.

The first mention of this parasite in the United States was made by Salisbury in 1868, who found the ova in the urine. Some years later (1886) Guiteras called attention to the presence of the embryos in the South, reporting four cases from Key West and one from Charleston, S. C. Only a little later De Saussure published a clinical history of twenty-two cases, also from Charleston. Since then many cases have been reported in the Gulf and South Atlantic States, many of which have been undoubtedly imported, but indigenous cases are not wanting, and one concerns a woman who had always lived in Pennsylvania. The last account by Lothrop and Pratt gives a most extensive and valuable study of two cases in Boston imported from the Barbadoes, and includes important new data on the characteristics of the adult worms.

Pathology.—The adult worm was first found in 1876, by the elder Bancroft, in a lymphatic abscess of the arm and subsequently in a hydrocele. The two sexes are found coiled together, and probably live for some time. Since then this discovery has been abundantly confirmed. Manson has shown that the species normally occurs in the lymphatic vessels, and that the embryos, as well as the adults, rarely also gain the circulation by way of the thoracic duct. The embryonic blood filariæ were first observed by Demarquay, of Paris, in a man from Havana, who was suffering from chylocele. The name *F. sanguinis hominis*, first used for these embryos by Lewis in India, has been applied to several different embryos, which Manson has distinguished by appropriate names. Whether they belong to different species or are stages of development in one or two forms is still unsettled, though I am inclined to accept their specific independence. Such embryos have been reported from urine, tears (?), and secretion of the Meibomian glands as well as from the blood in cases of chyluria and elephantiasis, and also in apparently healthy individuals. In the Barbadoes nearly thirteen per cent. of the persons examined were infected, and yet two-thirds of the infected cases manifested no external sign of the disease.

Manson was also the first to establish the periodicity of the embryos, as those of this species appear in the blood toward evening, increase in numbers during the night, and disappear in the morning. Manson views the "filarial periodicity as an adaptation of the habits of the filaria to those of the mosquito, the intermediary host indispensable to the future life of the parasite." But since it has been shown that by reversing the period of sleep the habits of the embryo filariæ may be reversed also, the explanation of von Linstow appears more probable, namely, that the tonus of the capillaries is reduced during sleep; and thus the embryos, which are too large to enter them during the day, find entrance possible owing to the increased size of the vessels. Manson found the embryos massed in large arteries and irregularly scattered through the capillaries in the day time.

The presence of embryos in the blood is evidence of the parasitism of the adult in some part of the lymph system. The duration of life of both adult and larvæ is entirely unknown; for the former, however, it is certainly several years. So far as known the embryos do not bring about pathological changes, though leucocytosis with an increase of eosinophiles is noted in early stages, to disappear later. The adults occlude large lymphatics and produce lymph stasis with resulting dilatation of the lymphatics. The clinical manifestations depend upon lymphatic obstructions and give rise to both general symptoms and local, which latter vary widely according to the part involved and to possible modification by infective processes.

An estimate has been made of from forty to fifty millions of embryos in the blood of a single man, and yet the individual suffered no apparent effect. It must be said, however, that the results of the parasite are brought about gradually; they are primarily a varicose condition of the lymphatics, giving rise to various conditions, such as chyluria, varicose inguinal glands, lymph scrotum, chylocele, lymphangitis, elephantiasis (*q. v.*). In the latter it is probable that the obstruction to the flow of the lymph produces mechanically the distention and excessive growth of such parts as arm, leg, scrotum, which is characteristic of the disease.

For examination Manson recommends a thick film of blood drawn at 8 to 9 P.M., when the embryos are most numerous. Fixing is unnecessary and the stain (fuchsin, gentian violet) is made by adding a few drops of an alcoholic solution of the dye to a watch glass of water. Overstaining is reducible by dilute acetic acid.

Prevention.—The protection of drinking-water from contamination by mosquitoes is strongly to be advised, and the case of the Friendly Islands is cited as evidence of the value of this measure. There forty per cent. of the males are affected by filariæ, all the people drinking from open pools; but the chiefs who have closed-water tanks rarely acquire the disease. It may, however, be urged in favor of mosquito inoculation that the chiefs are also least subject to mosquito bites. In any event, the protection of drinking-water and the destruction of useless pools will certainly reduce the number of mosquitoes, and consequently the extent of the disease, whether transmitted through drinking-water or by direct inoculation of a mosquito.

It must be noted that the presence of an infected individual is a distinct menace to the health of a community, since the widespread distribution of mosquitoes capable of acting as the intermediate host insures the possibility, and under some circumstances the certainty, of wider transmission of the disease. There is little doubt that the cases recorded from the Southern United States are primarily traceable to such introduction from the West Indies. The same explanation lies near at hand for those occasional cases which have been recorded in various localities, both here and abroad.

Filaria Magalhaesi R. Blanchard 1895.—(Syn.: *F. Bancrofti* Magalhaes 1892 *nec* Cobbold 1877.)

Body slender, elastic, resistant; cuticula heavy, cross striated. Female, 155 mm. long, 0.33 mm. broad at head, 0.285 mm. at neck, 0.7 mm. in maximum; vulva 2.56 mm. from cephalic extremity. Male, 83 mm. long, 0.407 mm. broad; tail with double spiral, on each side four preanal and four large postanal, papillæ of mulberry form (Fig. 3550); smaller (?) spicule 0.23 mm. long, longer unknown. Eggs 38 by 14 μ; embryos 0.3–0.35 mm. long and 5 μ broad with transversely striated cuticula.

Of this form Magalhaes discovered in Rio Janeiro two adults in the left cardiac ventricle of a man in whose blood embryonic filariæ were also present. It was at first wrongly assigned to *F. Bancrofti*, from which it is easily distinguished by the above characteristics. Like all Nematoda living in the heart the cuticula is tough to resist the powerful blood pressure, the body being like catgut, whereas *F. Bancrofti* is delicate and easily torn. The proportions of embryos and adults also differ materially.

The life history is unknown.

F. perstans Manson 1891.—(Syn.: *F. sanguinis hominis minor* Manson.)

The embryos, which have been known for some time, are found in the blood at all hours. They have no sheath, and measure only 0.18–0.23 mm. long by 4.5 μ broad, being thus much smaller than those previously described. Their continued presence in the capillaries may be due to this fact. The head is armed with a minute, exceedingly delicate filiform spine set on a papilla; this structure may be protruded and retracted rapidly. The embryo not only wriggles actively, but also travels about very rapidly. It is not numerous, but may be found in company with *F. nocturna* and *F. diurna*.

The adult was found by Daniels in a native of British Guiana, in whose blood both blunt- and sharp-tailed (*F. Ozzardi*) embryos were present. A male and a female lay in subperitoneal connective tissue. Manson also found an adult in one case of "sleeping sickness." Among the negroes on the west coast of Africa from one-third to one-half are infected, and most such show the earlier symptoms of this disease in nearly all cases of which *F. perstans* is present. Yet this parasite is found in apparently healthy individuals, so that its etiological relation to the disease mentioned is still a matter of doubt.

F. Ozzardi Manson 1897.—Male, 45 mm. long, 0.06 mm. broad; female, 70–80 mm. long by 0.12 mm. broad. Embryos in blood, without sheath, sharp-tailed, 0.173–0.240 mm. long by 4–5 μ broad.

The embryos were originally reported from the blood of Carib Indians from British Guiana, and were present in about fifty per cent. of the cases examined. At first both sharp- and blunt-tailed embryos were found together and were regarded as developmental stages of one species. Daniels found adults, chiefly females, in the mesentery, and in fat at various points in the peritoneal cavity; and in a later case two sets of adults, the one which is regarded here as belonging to this species, and the other, which was viewed by Manson as *F. perstans*, to which the blunt-tailed embryos are also assigned. The relation of the adults to these embryos is still a matter of considerable doubt.

In addition to the foregoing there are also several species of *Filaria*, known only by the embryonic form which inhabits the blood. While von Linstow regards them all as developmental phases of one species, I cannot concur in a conclusion so widely at variance with their differences in structure, habits, and distribution. They may be briefly noted as follows:

Filaria diurna Manson 1891.—Only free embryos of this species have been observed. They were found in the blood of negroes from the west coast of Africa. They appear in the peripheral circulation about 8 A.M., increase in numbers until noon, and decrease later, to disappear by 9 P.M. The periodicity was maintained for some weeks. As adults of *F. loa* were found in one of the cases, Manson regards it as likely that *F. diurna* is the larval form of that species.

Filaria Demarquayi Manson 1891.—The embryos of this species were found in the blood of apparently healthy natives of St. Vincent, and later also of St. Lucia, West Indies, and of New Guinea. They have also been reported very recently from other localities in the West Indies. They resemble the embryos of *F. Bancrofti* in general appearance; they are, however, only half so large (in dry smears) and they are without a sheath. Their presence in the superficial capillaries is constant day and night.

FIG. 3550.—Tail of Male *Filaria Magalhaesi*. Magnified. (After von Linstow.)

For convenient reference the characteristics of the blood filariæ may be given here in tabular form (p. 216) so far as they have been determined.

Filaria romanorum-orientalis Sarcani 1888 is a species observed in the blood of a Roumanian woman. The parasite measured 1 mm. long by 0.03 mm. broad, and had an alimentary canal and well developed sexual organs.

Family of the Trichocephalidæ. Body extremely elongated with two distinct regions, the longer anterior very slender and the shorter posterior more or less enlarged. Œsophagus very long, anus terminal. Males sometimes without a spicule, more often with a single simple one which possesses a sheath. Female with sim-