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Parasites:

Articles Contributed to Wood's Reference Handbook of the Medical Sciences, New Series,

by

Henry B. Ward.

1900—1904.
Contents:

Arachnida, October 1900, from Vol. I, pp. 428-437
Cestoda, April 1901, from Vol. II, pp. 779-794
Hirudinea, March 1902, from Vol. IV, pp. 700-703
Mosquitoes, Oct. 1902, from Vol. V, pp. 866-873
Nematoda, 1903, from Vol. VI, pp. 205-225
Parasites, April 1903, from Vol. VI, pp. 500-506
Trematoda, October 1903, from Vol. VII, pp. 860-873
Protozoa, August 1904, from Vol. VIII, pp. 527-549
Arachnida.
Appendicitis.

The first, and to a large extent justified by the necessities of the case. Should there exist a periappendicular abscess in front of the cecum, the connective tissue outside of the peritoneum under the transversalis will be edematous, and if the inflammation be great, edematous connective tissue will be noticed as soon as the tension of the external oblique muscle is divided. When the inflammation is confined to the region of the appendix, the transverse incision will enable the operator to look up the appendix, which can be drawn into the wound and removed. There is no necessity for making a very small incision. If the excellent advice of McBurney in regard to the opening of the wound is followed, the muscular layer has been followed, the integrity of the abdominal wall is assured after operation.

I find the removal of the appendix is best done as follows: After it has been drawn into the wound, the peritoneal cavity is to be walled off, and the appendix tied off, if voluminous, in segments; if not voluminous, by a single silk ligature. The peritoneal and muscular coats of the appendix are next to be cut circularly at a distance of about one-fourth of an inch from the cecum, but the incision is not to be extended through the mucous membrane. The muscular and peritoneal tissues are then pushed back, away from the mucous membrane, until the cecum is reached. An assistant should now grasp this demarcated cylindrical tube of muscle and wash it free by means of a pair of forceps, while the surgeon makes the dividing incision between the forceps. The free appendix is then to be removed, and the proximal end, close to the cecum, well touched with pure carbolic acid. The operator may tie the upper part of the appendix before cutting it down, and he may seem to do as well without such tying as with it. The stump of the appendix is to be turned into the cecum, and the peritoneal surfaces of the appendix cuff are to be brought together by means of a Lambert suture, thereby invaginating the stump. If there is any doubt as to what is the condition of affairs, the operator may pass a probe into the cecum after removal of the artery forceps from the mucous membrane of the appendix, but this seems to be, I think, needless. The wall of the cecum having been united over the invaginated end, and the same Lambert suture is to be employed in closing in the stump of the meso-appendix. Nothing but peritoneum is then visible. The operator may apply additional sutures to the peritoneal surface, if he so feels inclined. As a rule it is my custom to do this. The wound is cleaned and wiped with gauze, and the gut is pushed back into the abdominal cavity. The peritoneum is then sutured with fine silk, and the two layers of muscle are united separately with silver wire or other material, as the operator prefers. Finally, the skin edges are brought together. Silkworm gut or silver is my preference here. When a periappendicular abscess exists, and I find it necessary to drain the cavity, I bring the ends of the gauze to the surface for drainage, and close the edges of the wound lightly with layers of removable sutures; for when drainage is employed, my burried sutures are apt to become infected and to give trouble, as drainage precludes absolute cleanliness. If the appendix is swollen and stiff and cannot be invaginated, it is a good plan to tie a string around the base, to cut off that part of the appendix which is distal to the string, and then to leave the string to come away with the remainder of the appendix. It is by far the best to remove the entire appendix, if possible.

It is very comfortable for the operator to know that the appendix has been removed and that that source of trouble is eliminated from consideration. Whenever, therefore, it is necessary to do so, the appendix is to be taken away. But it cannot be done in a certain number of cases without serious danger to the patient; hence in such cases it must be left. Sometimes no trouble is ever experienced from an appendix which has not been seen; but in other cases it may be necessary to do a secondary operation for the removal of the appendix. A second operation is undertaken when the inflammatory area is in a quiescent state. Secondary operations and those undertaken for chronic appendicitis are very successful. When general septic peritonitis is present, the opening is made large enough to allow a free entrance of the fingers. The division of life takes precedence of every other consideration. Hence the opening into the belly will be effected by an incision sufficiently long to enable the operator to reach all the seat of disease. Pars and fasciae are to be evacuated; the walls of the cecum is to be a sufficiently cleaned, dry gauze or gauze wrung out in hot salt solution being used for the purpose; any lymph that may be present should be removed when possible; and it may be thought best (although I have not done it) to wash out the peritoneal cavity, and to put in an ample course of cold saline solution until it will be employed for this purpose. I think I have had as good results by using dry gauze, or gauze wrung out, as stated already, in hot salt solution. The places where pus must be sought for and removed are the following: the outer side of the ascending colon, below the liver, the pelvic cavity, the side of the rectum, and between the folds of the small intestine. If necessary, the intestines are to be taken from the belly cavity, wiped and cleared outside, but much shock follows such eversion. The peritoneum is to be dried, and the second layer of Lembert suture will be employed for this purpose. If the peritonitis has been cleaned, I think the recovery of the patient is aided by laying large strands of gauze in every direction in the abdomen, as has been already referred to. The ends of these, but not the gauze, which must be left, are tied together, for the prevention of any possible chance to the number of strands of gauze which a general peritoneal infection may call for. It may be wise in some cases, in order to provide more direct drainage, to make an opening at the back of the belly through the lumbar region.

In general septic peritonitis the bowels usually refuse to act, and, when this is the case, it may be well, as was first suggested by Dr. McCosh, of New York, to inject into the upper part of the small intestine, before the abdomen is closed, a solution of rooth of ferrocyanide of potassium in water. In order to accomplish this it will be necessary first to pass a small cannula through the intestinal wall. Then, after all the solution has been injected, the hole made by the cannula can be closed by a single Lambert's suture.

Operation for Chronic Appendicitis.—The best time for operating, in a case of recurrent attacks of appendicitis, is during the interval between two attacks, say two or three weeks after the subsidence of the symptoms. I have performed it has not been an attack of unusual severity. In the latter case the operation should be deferred for a somewhat longer period. The reason why an operation should not be done sooner is that sufficient time must be allowed to elapse for the irritation of the peritoneal lymph to be absorbed, so that any pus that may have collected within the appendix may have time to escape.
into the caecum, and finally that any remaining inflammation may subside completely before the abdomen is opened. It is interesting to note that when inflammation has been excessive, an operation undertaken a number of weeks afterward will find the adhesions thin and weak. It may be expedient to wait even longer, but such a waiting should be permitted only when the patient is directly under the eye of the surgeon, who can intervene at any moment, should another attack occur.

As the steps of the operation have already been described, it will not be necessary to go over this ground a second time. I will simply add that in these chronic cases, even if there is present a somewhat severe character, it is often a difficult matter to find the appendix, or, if we do find it, to recognize at what point its free end lies. In such cases, the shortest way is probably to divide the appendix across, between two pairs of artery forceps, and then to work each end free from adhesions. In this way there will be no special difficulty in reaching the point where the appendix springs from the caecum. Whenever this can be done we should cover raw surfaces over with peritoneum.

L. M. I. Tiffney.

APYONIM.—This is a yellow, crystalline powder, introduced as a substitute for auramine (yellow pyr-o-ta-nin) in ophthalmic practice. It is slightly soluble in water, freely so in alcohol, and it is very efficacious as an antiseptic and stimulant in conjunctival disease, and in purulent keratitis.

W. A. Bostedt.

AQUIFOLIACEÆ or ILICINEÆ.—(The Ilex or Holly family.) A family of three genera and some two hundred species, chiefly of North and South America. It is chiefly notable for the presence of an appreciable amount of caffar in the leaves of at least two species, on account of which they have been used as beverages (see Maté and Caxixi). Other species have been used as bitter tonics and alternatives (see Alder, Black, and Holly).

H. H. Rousby.

ARACEÆ or AROIDEÆ.—(The Arum family.) A large family, of more than one hundred genera, growing mostly in the tropics of both hemispheres. Many species, as the cultivated calat, are highly ornamental. Calóoxalis produces an important starch-yielding corn, zoënthon, an edible fruit. Many of the tropical species are known as poisons, but their constituents and actions are little known. It is remarkable that a few northern species in the genera spathcal, auros, arum, and arbores, should represent the same affinities as the southern species of the family, and more active agents may be expected to be made known in it in future.

H. H. Rousby.

ARACHNIDA.—In the branch or phylum Arthropoda, characterized by bilateral symmetry, by metameric segmentation of a heteronomous type, and by the possession of jointed appendages, typically a single pair for each segment of the body, may be distinguished five great groups: the Crustacea, including crabs, lobsters, water fleas, etc.; the Ochichophora, including but a single genus, Peripatus; the Myriapoda, including millipedes, centipedes, etc.; the Insecta, including the true insects; and the Arachnida or Arachnoidea. The latter may be defined as air-breathing arthropoda, characterized by the fusion of head and thorax into a single region, the cephalothorax, which is without antenna, but bears two pairs of appendages more or less closely connected with the mouth, and four pairs of walking legs. The abdomen, which may or may not be segmented, is usually distinct from the cephalothorax, though in the mites it is fused with it.

The class Arachnida is subdivided by various authorities into from seven to nine orders, among which are the Scorpiones or true scorpions, the Pseudoscorpiones or book-scorpions, the Phalangida or "Daddy Long-legs," the Araneida or true spiders, the Atracida or mites, and the Lingulataida.

The true scorpions have the power to inflict a painful wound by the sting located at the tip of the abdomen. In the case of large tropical species the effect of the sting may even cause death in small children, but only in the most exceptional cases does it seriously affect an adult. There is injected at the time a quantity of poison from a gland in the last joint of the abdomen; its action is in general to irritate nerve centres while at the same time producing a paralysis of motor nerves. The sting of the smaller species found in the United States is harmless, giving rise to a slight irritation, which lasts at most seven or eight days. Mr. Herbert H. Smith, the well-known collector in South and Central America and the West Indies, enjoys an evil reg symptoms and results in a number of carefully observed instances, says: "Probably death might result in some cases, as (if reports are true) it does, rarely, from bee stings. . . . My wife was stung by a small one; the wound was exceedingly painful. By the advice of a servant, she held the finger for an hour in hot sweet oil, mixed with an equal measure of huananum. There was no swelling and three hours after all pain had left her."

Among the spiders there are those that are able to plague the human skin by the action of the jaws or chelicera which also contain the orifices of a pair of poison glands. The effect of a spider's bite on an adult has, however, been much exaggerated; of itself the bite produces at most a slight dermal swelling which soon disappears. The large hairy theraphicides, popularly known as tarantulas, are not to be called dangerous. Their bite is painful, but the inflammation, though often violent, subsides rapidly. On the other hand, several cases on record of death from spider's bite have been traced to a small spider (Latrodectus mactans) which is related to supposedly poisonous spiders in other countries of the world, and it is not unlikely that the spiders of this genus secrete a more powerful fluid than others. The condition of the patient, his susceptibility to poisons, and other important facts are not on record in these cases, and it may happen that the chance introduction of extraneous matter through the bite has given rise to the more serious and fatal results noted. There are no spiders in this country of which it may positively be affirmed that they are venomous, though certain South American species enjoy an evil reputation which is undoubtedly well founded.

Order LINGUATULIDÆ. The highly modified forms included in this group have a certain superficial resemblance to tapeworms, from which, however, they differ radically in structure. Their closest affinities are doubtless to be found among the arachnids of which they are here considered as an order.

The body (Fig. 243) is elongate, cylindrical or flattened; the anterior end (cephalothorax) is more or less clearly marked off from the rest (abdomen), which is subdivided by annulations variable in number and distinctness. At the blunter, anterior end the mouth is located on the ventral surface and provided on either side with two protractile hooks, contained in sheaths or pockets. These hooks represent the mouth parts of other arachnids.
while other appendages are entirely lacking. There is no special respiratory apparatus, and the so-called stigmata are but the orifices of dermal glands. At the posterior end may be found the anal opening.

The lingual slits are of separate sexes, the males being much the smaller. The female genital pore is located near the anus, the male on the ventral surface near the anterior end of the abdomen. The adults live in the nasal cavities and lungs of mammals or reptiles, and the eggs, produced here in large numbers, must be imported by chance into a suitable secondary host in which they give rise to tetrapod, acariform embryos (Fig. 244, a) that metamorphose into a second stage (zygapophysis, Fig. 244, e), manifesting the main features of the adult. By a migration usually semi-passive, this form reaches the primary host and attains full development in it.

*Lingulata Fröhlich.*—Body flattened, with arched dorsum and crenated margins. Body cavity extending into the lateral regions of the rings (pectinate).

*Lingulata rivularia* Pilger = *Pentastomum tommoides* Rud.—Larva = *Pentastomum denticulatum* Rud. and *P. serratum* Fröhlich.—Body lanceolate, attenuated posterial; head rounded, annuli circa 90, hooks acuminate, enlarged toward the base, with basal joint elongated proximad. Female 80-100 mm. long, 8-10 mm. broad anteriorly, 2 mm. posteriorly. Male 18-20 mm. long by 3 mm. broad, decreasing to 0.5 mm.

The adult inhabits the nasal cavities of many mammals, particularly the carnivora, among which the dog is perhaps most commonly infested. The larva occurs in the viscera of the herbivorous mammals. The masses of eggs containing well-developed embryos are deposited by the adult female in the nasal passages, distributed over grass, etc., with which they are swallowed chieflj by rabbits, but even, as on salads, by man himself. Hatched in the stomach the larva penetrates the intestinal wall and encysts in liver or mesentery, where after several ecysis covering a period of from five to six months, they reach the second stage, characterized by the rows of retrorse spines on each annulus. From the liver they may, as some maintain, wander out actively and if eaten by a dog reach the nasal cavities directly; or they may await the consumption of the flesh by some carnivorous form, in which case they are set free in the stomach and wander through the tissue to the lung and thence by the air passages to their final location. Some authorities deny the possibility of the larva deserting its cyst and wandering out, and maintain that the transmission is always passive.

Rare instances of the occurrence of the adult in man are on record, probably due to the consumption of poorly cooked flesh (mutton) containing the larve. The larve (Fig. 245) has been reported frequently as a human parasite, chiefly from Germany and Austria. Most commonly found in the liver, it has also been met with in other viscera. Here it occurs in sharply defined yellow tumors, embedded in the substance of the liver or protruding somewhat from its surface. The tough capsule contains caseous or calcaneous contents, and varies in diameter from about 1 cm. to the size of a pea. The capsules are less frequently found scattered irregularly over the surface of the peritonum. The parasite is probably innocuous, as its presence has not been suspected previous to autopsies, at which Zenker found it in Dresden 9 times in 168 cases, Heschl at Vienna 5 times in 20; Klebs at Basel, however, only twice in 1,914 cases. I have found no record of its presence in man in this country, although it has been reported rarely from other hosts (rabbit and cattle).

*Porecephalus.*—Body cylindrical; body cavity continuous.

*Porecephalus moniliformis* Diesing.—Larva = *Pentastomum constrictum* von Siebold. Annulli about 20, separated from one another by a wide interval. Female 70-95 mm. in length, 6-7 mm. broad, male 13-17 mm. in length.

The adult is very incompletely known; it occurs in the African pythons. The larva has been reported from monkeys and the giraffe. It has also been found seven times at autopsies of negroes in Egypt and even of English soldiers in African colonies. Since it was found encysted in the liver, and death resulted from peritonitis, there is room for the belief of some authorities that the parasites could not have been the cause, but were merely accidentally present in these cases.

The parasites are throughout of small size, even the largest ticks attaining a length of only half an inch and the majority being but a fraction of this. The body is circular or oval in outline, with flattened ventral surface and arched dorsal. Ordinarily it manifests no separation into parts, though in some forms a distinct groove makes two regions distinguishable. While the skin is commonly marked by transverse striations or folds, traces of metameric segmentation are only rarely to be found. The chitinous covering is frequently provided with plates or shields, and bristles are characteristically present. A small projection (rostrum or capitulum) carries the mouth parts, which are often more or less fused into a beak and modified for biting, piercing, or sucking. As mouth parts are distinguished (1) the mandibles or chelicere; (2) maxillipeds or pedipalpi, the most prominent part of which are the jointed mobile structures, located at the sides of the mandibles. The lower lip (hypostome), anterior and inferior to the mandibles, is ordinarily fused to their bases.

The four pairs of legs, composed of from three to eight joints each, are terminated by claws, bristles, or suckers of various sorts. They may be attached directly to the skin or reinforced by a chitinous framework (epimeres) which may join to form a median ventral ridge (sternum). A special respiratory (tracheal) system is lacking in most parasites, though present in some; it opens by paired stigmata with sieve-plate coverings (peri- tritomes) the location of which is characteristic for various groups. Eyes are also usually wanting in the parasitic forms.

The separate sexes may be distinguished generally by difference in size in some forms a marked sexual dimorphism exists. The genital orifice is surrounded by a system of chitinous thickenings known in the male as the epipandrium and in the female as the epigynium. The vulva serves as birth opening, whereas a special copulatory orifice occurs at the posterior end of the abdomen. The acarids are usually oviparous, and from
the egg emerges a hexapod larva which metamorphoses into an octopod nymph, and finally by the development of the sexual organs becomes adult. This metamorphosis is accompanied by a variable number of moults, and in the Sarcoptide by histolysis and complete regression of the animal at each ecysis.

The following table, taken from Railliet, will be convenient in recognizing the various sub-orders and families:

<table>
<thead>
<tr>
<th><strong>Reference Handbook of the Medical Sciences</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Arachnida</strong></td>
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<tr>
<td><strong>Acarina</strong></td>
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</table>

- **Dermatophagoides**
  - Small, elongated mites
  - Male: terminal pair of legs shorter than posterior pair
  - Female: terminal pair of legs longer than posterior pair

**Demodex (the Follicle Mites).** Small, elongated mites; anterior region undivided, in adult with rostrum and four pairs of short legs; the posterior transversely striated, without appendages. Tracheae, stigmata, and eyes wanting. No marked sexual dimorphism. Both deep into the epidermis, with four pairs of rudimentary legs. Parasites of hair follicles and sebaceous glands of mammals.

**Demodex follicularum** (G. Simon), *D. follic. var. hominii* and *D. follic. var. canis*. Rostrum short, anterior region of body approximately one-third of total length. Egg oviform. Male 0.3 mm long, 0.4 mm broad; female 0.38 mm by 0.45 mm.

This form, which presents a characteristic appearance (Fig. 246), is a common parasite of the sebaceous glands of the human skin. It is easily discovered in the sebaceous glands of the nose, lips, and forehead; also in the ceruminous and Meibomian glands, and from the abdominal pubic regions. Normally the mites rest in the gland, head inward (Fig. 247), and a few are present in each gland; occasional increase in numbers is said to give rise to stoppage of the duct and from five to twenty may be found in a comedo plug. The statements of some authors, according to which these parasites occur in two-thirds of the persons examined, are held by other investigators to be far beyond the usual percentage of infection. Precise data are lacking. Henle, who discovered this species in 1841, obtained living specimens of the mite from a cadaver six days after death. In spite of the fact that this species is difficult to distinguish from related forms of the dog, cat, and other domestic animals, with a single doubtful exception, no case of infection transmitted in other direction is on record, and all efforts to accomplish this experimentally have failed.

Although *D. canis* gives rise in the dog to a serious dermal disease (Fig. 247) which is rather difficult to handle, no similar difficulty is reported for man with *D. follicularum*, even in the case of those individuals habitually regardless of personal cleanliness; and an etiological relation between these mites and acne, as maintained by various observers, has not been satisfactorily demonstrated.

**Sarcoptes.** Small, pale mites, with soft body, not elongated, separated into two regions by a more or less distinct transverse groove. Mandibles chelate, maxillary palpi styli form. Four pairs of five-jointed legs with epimera, in two groups corresponding to the regions of the body, terminal joints (tarsi) with one or two claws, a sucker, or both, or with long bristle. Trachee wanting. Sexual dimorphism general. Metamorphosis with hexapod larva and two nymphs, often complicated by the appearance of a hypoplastic nymph.

Of the seven sub-families only the Sarcoptine or Itch mites, and the Tyroglyphine or Cheese mites, are of importance here.

**Sarcoptes (the Itch Mite of Mammals).** Body round or slightly oval. Rostrum short, and thick; posterior feet entirely or nearly hidden by the body. Tarsal suckers with long, simple peduncle; in female on the first and second pair of legs, in the male also on the fourth pair. Anus terminal.

Some authors distinguish but a single species with numerous varieties; it seems better, however, in spite of the often insignificant and in part inconstant specific differences thus far known, to follow the later authorities in regarding these forms as different species, even though physiological characters must still be used in part for...
their distinction. They apparently do not interbreed, and certainly are permanent only on the appropriate host from which in some cases they cannot be transferred to any other, even for a short time, though usually such

transfer results in temporary existence without the disease reaching a serious stage and often disappearing spontaneously.

**Sarcoptes scabiei** (de Geer) (the Human Itch), = *Acarus sivo*, A. caucovium, Linn.; *Acarus scabiei* de Geer; *Sarcoptes hominis* Hering; *S. scabiei* var. hominis Mégain. Dorsal scales pointed, longer than broad. Anterior projections of epinidrium short, scarcely reaching the epimeres. Posterior spines long, pointed. Male (Fig. 248) 0.2-0.24 mm. long, 0.15-0.2 mm. broad; female (Fig. 248) 0.3 to 0.45 mm. long, 0.25 to 0.35 mm. broad.

The history of the disease caused by the itch mite is connected with some of the most momentous disputes in medicine. The complaint is recorded in the earliest writings, and the mite may have been known to Aristotle; but the Arabian physicians in the twelfth century were the first to state clearly the existence of a minute characteristic animal which could be removed from the skin and “eracked” on the finger nail. The galleries bored in the skin were discovered in the fourteenth century, and the mite described and figured clearly in the seventeenth, while in a letter to the famous Italian anatomist Redi, in 1637, Bonomo and Cestoni gave a precise description and figures of the mites and their eggs, inferring correctly that the animals were of separate sexes and were the actual cause of the disease, so that a cure depended upon their complete destruction. Others of prominence in dermatology, however, attributed the trouble rather to “destructive juices,” either denying the existence of the mites or their relation to the itch, or holding that a poison was inoculated into the blood by their bite. Early in this century the French Academy offered a prize for the rediscovery of the mite, whereupon a certain Dr.

**REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.**

**Fig. 248.**—Sarcoptes scabiei, female, in Dorsal Aspect. (After Canestrini.) × 130 diameters. a, b, c, Scales.

**Fig. 249.**—Sarcoptes scabiei, male, from Ventral Surface. × 360 diameters. (After Canestrini.)

1687, Gales palmed off cheese mites on a learned jury, pocketing both the medals and the prize! Finally, in 1834, Remucci demonstrated in Paris the method by which Corsican women were accustomed to remove the mite on the point of a needle from the end of its tunnel, and thus established its actual presence in the disease. The male was discovered by Krämer in 1845, and the pathology of the disease established upon unimpeachable experimental and clinical evidence particularly by Hebra.

The mite appears to the naked eye white and glistening, and was aptly described by Bouin as like a little bladder of water. Viewed under the microscope there is seen a tortoise-shaped head with a pair of short, heavy legs on either side, which have a framework of chitinous bands like the garters of an Italian bandit. The third and fourth pairs of legs are concealed under the posterior

**Fig. 250.**—Sarcoptes scabiei. Impregnated female (c) in cuticula. (After Railliet; semi-diagrammatic figure adapted from Gerlach.) a, or, or', on. Eggs, those farther away from the mite being older; c, an empty egg shell; o, orifice through which a larva has escaped; e, excrementa.
margin of the body. The male is much smaller than the female and has the fourth pair of legs terminated by a sucker instead of the bristle which is on the fourth pair in the female. There is also on the ventral surface of the male a complicated chitinous framework wanting in the female.

The human itch mite lives in the skin in which the female tunnels an irregular winding passage, where she passes her entire existence (Fig. 250). These burrows vary in length from a few millimetres to two or more centimetres and are excavated prefabrically where the skin is thin, as between the fingers, in elbow or knee joint, on mammary or penile. The gallery, directed first downward through the stratum corneum, is attended through the softer cells of the Malpighian layer just above the papille. Eggs and fecal matter fill the most of this tunnel, at the inner end of which may be found the female. The male is much rarer; its existence is passed on the surface of the skin, hiding under scales and in furrows. After an incubation of only a few days there emerges from the egg a hexapod larva, which bores through the roof of the tunnel and gains the surface of the skin, where after three or four molts and the acquisition of a fourth pair of legs the development of

The disease is produced by the transfer of the parasite by actual contact from an infected person to one not infected. Such infection must transport both sexes, or at least pregnant females, and under such conditions that they can successfully form burrows. In spite of the fact that in large continental hospitals and clinics, yearly thousands of cases are treated and handled by nurses and students without any precautions whatever in the way of disinfection, not trouble is some, if any, on the disease.

Infection is easily and most commonly brought about by long-continued and intimate contact, and the nocturnal habits assigned by some to these mites are due to their increased activity under the influence of the warmth of the body. The disease is far more common among men and of such classes and occupations as are wont to sleep together. A transient infection may be induced by the transfer of this species to the horse, dog, or ape, but the cat is apparently immune toward it. attack the natives amongst whom there are numerous which gradually grows in intensity and becomes an extensive pruritus, accompanied by eczematous inflammation with the formation of papules and vesicles. The malady increases in severity with duration, and especially in result of scratching, until it may acquire the character of a severe eczema, the vesicles and pustules being associated with extreme excoriations and the formation of crusts. The itch may be confused with eczema and pediculosis, which latter may in fact coexist with it. The first step in the treatment of the itch is the absolute destruction of the entire colony of mites and their eggs, for which purpose various sulphur ointments are successfully employed. Naphthol is also highly recommended. In severe cases some eczema remains to be treated after the destruction of the mites.

It is important to record here from Nuttall the view of Joly that the itch mites may serve at times as carriers of lepra bacilli. In parts of Norway where much leprosy prevails, these mites are abundant, and, together with pediculi, they are usually found and the poorest classes in Algeria, from which the greatest number of lepers come. “In the Soudan the sarcoptes occur on almost all the dogs [most probably not the S. scabiei—W. J.] and often attack the natives amongst whom are numerous lepers. It seems to me that the possibility of this mode of transfer cannot be denied, and it is also conceivable that the pathological changes produced in the skin by the parasites may even favor the multiplication of the bacilli.”

Sarcoptes scabiei, var. lupi Méggin. Dorsal scales obsolete. Anterior projections of epidermis well developed, reaching the epinerves. Posterior spines long, pointed, curvently bent. Male 0.17 by 0.15 mm.; female 0.41 by 0.34 mm.

This form, though much like the preceding, produces such radically dissimilar effects on the human skin that we are forced to regard it as a distinct species. It was first discovered in Christiana, whence the name Norway itch, by which it is commonly known, though cases have been reported in most European nations and one from this country (Indianapolis) by Hessler.

The malady is easily distinguished from the common itch by the formation of coarse crusts, which, however, do not usually make their appearance for some years. This gives color to the view that this form of the itch finds its explanation in individual differences on the part of the host rather than in the parasite. The fact view is the formation of crusts several millimetres in thickness and several centimetres in extent, the enormous numbers of mites found in the midst of these masses, and the attacks of the mites on face and scalp where the common itch mite does not occur. This species is apparently transmitted with great ease, and its attacks do not readily yield to treatment. Méggin’s idea that it is identical with the sarcoptes of the wolf is entirely untenable.

The case reported by Hessler apparently belongs here, though the author did not differentiate the parasite
found from the ordinary itch mite. The patient was partially paralyzed and entirely helpless—hence we may infer absence of the ordinary scratching; its sequelae are apparently entirely wanting. The body of the patient was literally covered with thick, yellowish-white, leathery scales, the largest measuring 25 mm. in diameter and nearly 3 mm. thick; these scales consisted merely of proliferated epithelial cells, and bloody or scabby crusts were not present. They were, however, produced by moderate friction. In the scales on the body the author estimates the number of egg cases and eggs as seven million of which one-half to three-fourths were empty, and the number of mites as two million of which only a small fraction were living.

The following forms, normally parasitic on other hosts, may be transmitted accidentally or experimentally to man and give rise to an itch, rarely severe and usually transitory. No doubt other forms yet undescribed will fall in this same category. Besides man, only the most common host is given for each species.

*S. anchenii.* Male 0.24 by 0.18 mm.; female 0.34 by 0.26 mm. On the llama; transmitted to attendants, requiring treatment to dislodge.

*S. ovins.* Male 0.19 to 0.23 by 0.16 to 0.18 mm.; female 0.3 to 0.43 by 0.29 to 0.35 mm. On the dog; frequently transmitted to man, variable in severity.

*S. caprae.* Male 0.245 by 0.188 mm.; female, 0.345 by 0.342 mm. On the goat; readily transmitted to man; induces an itch of great severity.

*S. dromedarii.* Male 0.29 by 0.18 mm.; female, 0.36 by 0.33 mm. On the camel; readily transmissible and severe; in Egypt almost all camel drivers are affected; the Senegal negroes call the complaint lartbsch.

*S. equi.* Male 0.22 to 0.28 by 0.15 to 0.2 mm.; female 0.43 to 0.5 by 0.31 to 0.37 mm. On the horse; rare on man, transitory and usually disappears spontaneously.

*S. leonis.* Male 0.55 by 0.18 mm.; female, 0.43 by 0.33 mm. On the lion; easily transmitted to man; disappears spontaneously in thirty to forty days.

*S. orix.* Male 0.22 by 0.16 mm.; female, 0.314 by 0.3 mm. On the sheep; very rarely transmitted to man, if indeed at all.

*S. satu.* Male 0.25 to 0.35 by 0.19 to 0.3 mm.; female, 0.35 to 0.5 by 0.29 to 0.39 mm. On the pig; transmitted to man, sometimes disappears, sometimes grows worse.

*S. vulpis.* Male 0.245 by 0.185 mm.; female, 0.442 by 0.315 mm. On the fox; its transmission to man rests on doubtful evidence.

*S. wombati.* Species not described in detail; forms a crustaceous itch on the womb; readily transmitted to man; produces a type of itch intense and unlike the ordinary form; yields readily to treatment.

*Notoedres cati* (Hering = *Scroptes minor* Försteb). Tarsal suckers with long, unjointed pedicile: in the female on the first and second pairs of legs, in the male also on the fourth. Anus dorsal, near posterior margin of abdomen. Dorsal scales obtuse. Male (Fig. 232; C) 0.14 to 0.15 by 0.12 to 0.125 mm.; female (Fig. 232, A, B) 0.21 to 0.23 by 0.16 to 0.175 mm.

This, the itch mite of the cat, attacks on its normal host the skin of the head and ears, and induces a serious, often highly epizootic malady with a termination usually fatal. This species is of importance here because of its easy transmission to man. On the latter it produces a limited itch which disappears spontaneously at the end of from ten to twenty days. It occurs on cats in Lincoln, Nebr., and doubtless elsewhere; no cases of transmitted infection are, however, on record here.

The other genera and species of itch mites common to domesticated animals are not known to be transmissible to man.

Sub-family Tyroglyphinae (Cheese Mites).—Minute forms with soft body, without eyes or trichae. Integument never uniformly striated, but smooth and granulated or irregularly verrucose. Last leg with claw and usually also with foliate, non-pedunculate vesicle.

These mites (Fig. 233) live in dry or slowly decaying materials (flour, sugar, cheese, anatomical preparations, etc.).

From their minute size and abundant occurrence they are liable to be introduced on to or even into the human body, and may even make the passage of the alimentary canal without being entirely destroyed. From their presence on the body or in fecal matter under circumstances of disease they have been often reported as *corpora delicta.* In rare instances certain species
have been transitory parasites of man. Where abundant, as in old groceries orwarehouses, they have been known to give rise to a temporary, though often violent dermal irritation on employees handling the infected products, without the evil having been traced in all cases to any single species. Such a complaint is the "grocers' itch" of England. Since these are the most frequent pseudo-parasites with which the physician has to deal, extreme caution should be exercised in associating etiologically any species which belongs in this group with a case of disease in which it has been discovered.

Aleurobius farinii (De Geer). (The Flour Mite) = Tyrolyphus fariniae. Gervais. First pair of legs in male much heavier with spur on second joint. White, tip of legs pink. Female, average length 0.75 mm., female 0.56 mm. Cosmopolitan on flour, fruit, tobacco, cheese, and other organic material in process of alteration by age. This species is much more abundant than the following even in cheese, and has frequently been described as the species responsible of eventual differences. It was observed by Moniez as the cause of a cutaneous eruption on workmen unloading Russian wheat at Lille.

Tyrolyphus sivro (L.) (The Cheese Mite) = Acarus sivro, A. lactis, A. dysenterie L. Last pair of legs with both claws, increases the terminal joint short and with proximal sucker close to proximal end of terminal joint. Length 0.5 mm. Female, resembles the decomposing substances like the last, but rarer. This is the cheese mite reported by various authors from dysenteric stools and from urine. Its occurrence was undoubtedly accidental, and its harmless nature may be judged from the quantity taken daily in cheese everywhere and the absence in medical works of any record of consequent diseases. Yet Ziirn records that in certain districts where mites are raised to impart a peculiar flavor to the foies gras of certain cats, a gastric or intestinal catarrh is prevalent among consumers of the cheese which he attributes to the effect of the mites. As this species is abundant in old larded meat, its reported occurrence in poulticed wounds is easily explained. In cutaneous it is also abundant and in vanilla, where its presence has been associated with the vanilla complaint, a dermal eruption frequent among workers handling this product. The famous Acarus dysenterie of Linneaus, which was found abundantly in stools of one of his scholars and traced back to the wooden vessel from which the young man drank, was probably this species. It has, however, been reported but once since then from dysenteric stools, those of inf. in Prague, and the etiological relation may certainly be called in question.

Tyrolyphus longiro (Fig. 233), which is similar in habit to the last species, though less abundant, is easily distinguished by its larger size and more rapid movement. Its presence in cheese in 1880 as having been produced (1) by the electrical experiments of Cross on weak chemical solutions. The mummification of bodies in caves has been shown by recent investigations of Meguin to be due, in some cases at least, to chemical or atmospheric influences, but to the work of Tyrolyphus infestans, which is abundant in such localities. The external appearance of the body and organs of the mummy was well preserved, but microscopical examination showed the tissue to be filled with incalculable myriads of the mite in all stages of development.

Gamasidae (Beetle Mites).—Skin leathery, reinforced by cuticular plates; mandibles chelate, maxillae filiform; six-jointed legs terminated by two somewhat conical hooks. Stigmata lateral, between legs of second and fourth pair, with peritreme directed anteriorly. Without eyes.

The Gamasidae are abundant small mites, often free or semi-parasitic, in the latter case found on insects especially. Certain species are found on the body of the host, but are often very troublesome to man. Of the large number of forms which belong in the family only two need especial mention here.

Dermanyssus gallinae (de Geer) (The Poultry Mite). Body pyriform, slightly flattened; in the male 0.32 mm., in the female 0.7 to 0.75 by 0.4 mm. Color varies from white to dark red according to the contents of the alimentary canal. Legs stout, rather short. Peritreme extends as far as the base of the second pair of legs.

These mites (Fig. 254) swarm in the crevices of poultry houses and in the refuse of the floor, even living in the dung. At night they emerge from their hiding-places and suck the blood of the birds. Under circumstances they may extend their feeding area to an extent as to become a veritable pest, even to man himself. Many cases are on record in which blood-sucking mites and adults have been subject to repeated attacks of the mites, which give rise to an itching eruption of the skin. Naturally such instances are observed among persons having to handle fowl or to resort frequently to the poultry houses. Kitchenmeister, Railliet, and others record details of cases on the Continent; I have found none for this country.

Dermanyssus hiemalis (Hermann) (The Swallow Mite). Decidedly larger than the preceding, reaching a leg of 8 mm. Peritreme extends barely to the third pair of legs.

This species, which normally attacks the swallow, has been known to pass from the nests under the eaves into sleeping rooms and to attack the occupants of the room, giving rise to severe itching.

Trombidiidae (The Harvest Mites). Soft-skinned, velvety, often highly colored mites, with tracheal opening at the base of the rostrum or on the cephalothorax, and usually with eyes. Sucking rostrum with styliform mandibles and incisate palpi. Legs six-jointed, terminated by a double hook together with a small sucker.

Of the large number of terrestrial mites included in this family only a few species are parasitic, but some of these, though only occasionally attacking man, are among his most disagreeable chance parasites. Doubtless many other species than these noted here may be found to attack him in one place or another; it is desirable that accurate data regarding all such species be on record. Accords to Egly and others, these mites are the passive carriers of infectious agents, but Nutall doubts this and thinks the cutaneous affections produced by their presence on the skin are due to irritating secretions of the mites. The effect Méguin produced by injecting into the skin the dead bodies of one of the most toxic species tends to support this view. To secondary bacterial infection brought about by scratching the skin and to reduced virility of the latter referable to the mites, are to be attributed the extreme effects manifested.
in the formation in some cases of ulcers and running sores. *Ixodes ricinus* (Newport), *Ixodes dammini* (Newport). Male 0.08 by 0.2 mm., oval, with six pairs of bristles and a pyriform plate on the dorsal surface. Female cylindrical, 0.2 by 0.07 mm., with four pairs of bristles. When gravid with posterior region inflated to a sphere filled with developing eggs, nearly 2 mm. in diameter, viviparous. This form lives parasitically on insect larvae, particularly those of grain. Numerous cases of accidental parasitism on grain shovelers, or those otherwise engaged in handling it, are reported from different parts of France and Germany. The bite of the mite produces insufferable itching and excites a considerable cutaneous inflammation.

Similar troubles have been produced by *Tarsocrenus sinicarus* Kargell from Bulgar grain and *Pygmeaphorus incisatus* (Flemming) from Russian wheat. *Chelidus cutudinis* (Schrank). Male, rarely reddish in color, with broad hook on the palpi. Length, 0.3 mm. This mite occurs at times in old books or among dusty rags, but more commonly in stables, chicken or pigeon houses, in old feed bins and in tobacco stores, or wherever mice are abundant. In spite of its predacious habits, it has not been known to attack man, and its presence in febrile matter and in pus-collected from the ear, as reported in various medical works, was undoubtedly due to accidental introduction. When St. Peter's in London was restored, this form swarmed in myriads over workmen engaged in repairing the ancient tombs.

*Leptus irritans* Riley. Color brick or blood red; legs terminating in two stiff hairs. Mandibles tridentate at end. Length, 0.24 mm. (Fig. 255, C). Adult unknown.

This is the larval form of some unknown, probably plant-feeding species which under temptation adopts a habit as fatal for itself as it is uncomfortable for man. Brushed from grass or shrubbery on to human clothing, it finds its way to the skin into which it burrows until entirely buried. The resultant irritation varies considerably with the individual and in some cases produces extreme torture. The inflammation gives rise to a large red blotch with paler spots and spreads rapidly when the body is scratched in consequence of the itching.

This mite occurs over much of the eastern, central, and southern portion of this country, extending in the Mississippi valley as far north as central Iowa and being very abundant in parts of Indiana, Illinois, and Ohio, even as far north as the islands in Lake Erie. In Washington it is abundant from June throughout the summer, and farther south the season is longer. Osborn speaks of the same species as annoying in Southern Mexico in January. Those who are susceptible to the pest are accusd, on returning from field excursions, to resort at once to a hot bath with strong soap, or to the use of a wash of dilute carbolic acid to kill the mites before they become embedded in the skin. Dilute alcohol is also recommended. At this time it is also possible by close scrutiny to recognize the mites in the centre of the infested area and to remove them individually, thereby thus with the subsequent discomfort to a large extent.

It is interesting to note that the invasion of the human skin causes the death of the mite and prevents its reaching maturity, a perforation habit being thus fatal to the species. As a result the adult form is not known, but as assumed to possibly one of the genus *Trombidium*.

*Leptus americana* Riley (Fig. 255, B) is an associated form, the effects of which are very similar. The Continental species is *L. contumelius* Shaw. Similar forms are known from all regions, among the most notable being *T. solnate* in Mexico, and the *Colorado* of Cuba deserve mention.

*Trombidium nodosum* Weyenberg from Uruguay and Argentine, which lives normally on an aster, is of like evil repute.

Some case of *Tytocnus montana* Moniez, a blind, rose-colored mite of the family Bedellidae or snouted mites, which was discovered on a large estate in Belgium where it first made its appearance in 1861 after an importation of Peruvian guano, illustrates the chance introduction of an undesirable species. Each year it appears at mid-summer and remains until frost, so abundant that it constitutes a veritable pest. It throws itself on man passing through the grass or shrubbery and produces an unsupportable itching, lasting several days.

*Amblyodectes* (Ticks).—The *Ixodides* are large mites possessing a tough leathery skin to which the six-jointed legs are attached directly. Their bodies are flattened in youth, but become more or less spherical with age. The rostrum or capitulum (Fig. 256) comprises (1) a flattened maxillo-labial hypostome; (2) two elongated mandibles inflated at the base but flattened and toed toward the terminal end of the palpi. The face is a smooth plate with the base of the fourth pair of legs. The larva is hexapedal, the nymphs octopedal. The adults manifest striking sexual dimorphism.

The ticks are temporary parasites of the land-living allantoco vertebrates, among which the hosts are chosen often, largely by chance. No one of them is regularly parasitic on man, but almost any of them may be upon occasion, and those species most frequently reported are so largely by virtue of their greater frequency in general or by reason of circumstances favoring their attachment in the particular instance rather than that they possess any characteristic affinity for this host.

Naturally abundant in woods and among underbrush the ticks attach themselves to such animals as pass, either reptiles, birds, or manmals. For the larve and nymphs this is most commonly the means of dispersion, but with the impregnated female the parasitism becomes more definite. With the rostrum implanted in the skin and anchored by the recurved teeth, the tick gorges itself with the blood of the host until the leathery body has swollen to the size of a casear bean, which it strongly resembles. Once fully satiated the female releases her hold and falls to the ground, where she deposits her eggs and perishes. If, however, the effort made to remove the female by force, only the greatest care prevents leaving the rostrum embedded in the flesh of...
the host, and at best a portion of the skin comes away with the tick.
A drop of turpentine, benzine, petroleum, or even melted butter or oil placed on the head of the tick will often succeed in causing it to loosen its hold and fall from the host. Or it may be torn or cut away, in which case the rostrum is left in the skin to be set free shortly

by suppuration. It is worth mentioning that dipping is now extensively practised to free cattle from the ticks which are the means of infection in Texas fever, though the method is still in the experimental stage.

The species which have been found upon man have not been reported with desirable accuracy. Among woodchoppers and others of similar habits, I am informed that the presence of ticks is by no means a rarity, though it rarely becomes a matter of medical record since the animal falls off or is removed by simple means in a brief time without noticeable sequelae. In a few cases, however, dangerous symptoms manifest themselves, demanding the attention of the physician. These complications may well be due, as Quilliet suggests, to the inoculation of infectious agents. Thus he says that Guadeloupe ticks carry “a sort of glanders,” due to a specific microorganism, and Blanchard believes that the bacillus of anthrax and tetanus may be also transported in this way. Nuttall, however, regards the evidence as unsatisfactory.

The two sub-families Ixodinae and Argasinae may be distinguished easily by the position of the rostrum, which is terminal in the former and, at least in the adult, below the anterior margin of the body in the latter.

*Ixodes hexagonus* (L.) (The Castor Bean Tick) = *I. ricinus* L. Male: brown oval, larger posteriorly, 2.5 mm. long by 1.5 mm. broad. Female: 4 mm. long and 3 mm. broad, or when gorged 10 to 11 mm. long by 6 to 7 mm. broad, ash gray tending to brown or yellow.

The marked sexual dimorphism manifested by this species was the reason that the male and female were originally described as different species. It is common in Europe and throughout the southern United States from Maryland to Kansas and California. As host it apparently prefers sheep, goat, or beef, less often horse, dog, cat, and even man. Numerous cases of septicaemia apparently resulting from the bite of this species are recorded by European authors. In Norway emphasis is laid on the importance of not tearing off the head of a tick that has begun to bore itself into the skin. This is undoubtedly a wise precaution, and the tick may be removed without damage to the skin by the use of butter, oil, gasolene, or turpentine as mentioned above.

*Ixodes hexagonus* Leach (The European Dog Tick). In color, form, and size much like the preceding, this form may be distinguished by the shorter rostrum (Fig. 257) and by the tarsi which are also shorter and inflated toward the end. The male (Fig. 257) of this species is also larger, measuring 3.5 to 4 mm. by 2 to 2.5 mm.

This, the common dog tick of Europe, occurs over the entire region east of the Rocky Mountains, where it is reported from a large number of hosts. Blanchard cites cases in which it has even penetrated below the human skin.

The presence of eyes distinguishes sufficiently the genus *Amblyomma*, which includes a large number of species, from *Ixodes*, as the absence of anal plates separates the former from *Hyalomma*, a genus not yet reported in this country; to this genus belongs the African or Senegal tick, common in tropical regions, especially of Africa, and introduced on cattle into subtropical lands adjacent thereto, where it has been frequently reported on man as the cause of intense fevers; probably the tick was only the agency in transporting the infection.

*Amblyomma americanum* Koch (The Lone Star Tick) = *Ixodes nebulosus* Packard. Male: body brownish red oval, much elongated posteriorly, 3 mm. long, 2.5 mm. broad. Female (young) colored like the male with a white spot on the back of the living animal. Length 4.5 mm., breadth 3 mm., increasing in gravid females to 8 by 13 mm. (Fig. 238).

This characteristic American species occurs from Labrador to Florida and Texas and is known from South America as well. It is common on cattle in the southern part of the United States, and is reported from other domesticated as well as wild species. Packard reports a case in which a specimen had penetrated into the arm of a young girl, forming there a tumor. It is said to be very annoying to man in the warmer portions of the country, and a correspondent in Texas writes that he removed several females from his own children before evening.

*Dermaeontor americanus* (L.) (The American Dog Tick) = *Ixodes americanus* Gervais, *I. napennsis* and *I. adi-

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**Fig. 257.—*Ixodes hexagonus*, Male, in Ventral Aspect. X 13. (After Neumann.)**

**Fig. 258.—*Amblyomma americanum*, Koch, Adult female. (Original.)**

**Fig. 259.—Dermaeontor americanus*, Dorsal view of male. X 10. (After Packard.)**

*Packard*. The body and margins of the legs are marked by silver-white lines and blotches. When gorged, the female measures as much as 14 mm. in length by 9 mm. in breadth.

This most common dog tick (Fig. 259) is reported from almost every State in the Union as well as from Labrador,
American species are scanty, but it is said to attack sleeping men and animals, producing in the former dermal irritation of a grave character.

The *Argas persicus*, or Mina bug, is an Eastern species of some reputation which is said to molest travellers in Persia, and the bite is believed to be extremely dangerous, and to be accompanied at times by serious consequences. The general report, according to which the bite of these ticks is especially dangerous during the hot months, may find its justification in the transmission by this means of some tropical disease germ, as has been demonstrated in the case of Texas fever. The acute symptoms which may be manifested at any season are believed to be due to a poisonous saliva, and the experiments of Méggin on a specimen kept in confinement for four years certainly do not demonstrate the hardness of chiggers of the tick. Bacteria may of course gain access to the wounds inflicted, which are possibly more prone to infection in consequence of the injurious influences of the secretions of the Argas. Depending on the character of the organism introduced, the later symptoms will naturally vary (Nuttall), *Argas sanciscii* of California and Mexico, which is very closely related to *A. persicus*, does not enjoy a similar reputation.

**Orythridae turcica**, found in the Gulf States and in Mexico, and *O. bolivae* of Central and South America, are forms not well known, which encroach upon our southern borders. The first is parasitic upon the pig and man. Its bite is painful and may produce dangerous symptoms. 

*Henry B. Ward.*

**Principal Articles Used.**


**Braun:** Die tierischen Parasiten des Menschen, zweite Aufl., Würzburg, 1895.

**Canevini und Kramer:** Demodiecta und Sarcoptida. Das Tierreich, 7. Lief., Berlin, 1899.

**Braun:** An Extreme Case of Parasitism. Indiana Academy of Science, 1893; also Amer. Naturalist, vol. xxvii., pp. 346-52, 1893.

**Leuckart:** Prei und Entwicklung d. Pentast., Leipzig, 1899.

**Murray:** Les parasites et les mites. Paris, 1880.


**Packard:** Guide to the Study of Insects, sixth edition, New York, 1878.

**Railliet:** Traité de zool. Méd. et Agric., 2me éd., Paris, 1889-95.


**Ward:** Poisonous Insects. Also smaller papers by the same and other authors.

**ARAGON, BATHS OF.**—These baths are located in the Amanz Hacienda, municiplty of Guadalup Hidalgo. The situation is 4 km. from the Guadalup Hidalgo and is accessible by the electric railway line between Mexico and Guadalup.

**According to an analysis by Prof. G. Mendoza the water is composed as follows:**

**One United States Gallon Contains:**

<table>
<thead>
<tr>
<th>Solids</th>
<th>Grains</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulfur</td>
<td>3.32</td>
</tr>
<tr>
<td>Sodium bicarbonate</td>
<td>3.42</td>
</tr>
<tr>
<td>Potassium bicarbonate</td>
<td>0.07</td>
</tr>
<tr>
<td>Calcium bicarbonate</td>
<td>0.15</td>
</tr>
<tr>
<td>Magnesium bicarbonate</td>
<td>0.16</td>
</tr>
<tr>
<td>Sodium chloride</td>
<td>0.38</td>
</tr>
<tr>
<td>Silica</td>
<td>5.08</td>
</tr>
<tr>
<td>Free chronic acid</td>
<td>4.85</td>
</tr>
</tbody>
</table>

**Total:** 18.50

The water is heavily charged with carbonic-acid gas. It has a temperature of 77° F. and a density of 1.021. It may be classified as a carbonated alkaline water, and possesses strong tonic properties. It has been found very useful in amenia, chlorosis, and kindred disorders.

*J. Ponce de Leon.*
ARALIACEÆ.—(The Ivy Family.) A family of some forty genera and about four hundred species, widely distributed through temperate and tropical regions of both the old and the new worlds. Its plants are highly ornamental, some, like the ivy, being extensively cultivated for this purpose. Medicinally, it is of note as yielding the famous ginsing. Its constituents are simply aromatic and possess special properties. The spike and several other species of aralia, were formerly very extensively used, and are still used to a considerable extent, for these properties. Some of them contain amaro-
cids in connection with their resins and volatile oils.

H. H. Reshly.

ARBOR VITÆ.—(Thuja.) The fresh tops of Thuja occidentalis L., Fam. Coniferæ. This is a North Ameri
can tree, growing abundantly in Canada and the Northern
states, used for couglia; aincture is prepared occasion
ally for external use upon ulcers, rheumatic joints. Etc.
Dose, 2 to 4 gm. An alcoholic fluid extract would be a
suitable preparation.

W. P. Balles.

ARACHON.—The town of Arcachon lies about thirty miles
southwest of Bordeaux, on the margin of a very
extensive salt-water lake, and some ten miles back from
the Atlantic coast. The modern origin of the town is
indicated by the motto inscribed upon its coat ofarms,
D'Arcachon, ouvrée 1647. This is also an indication of the
former character of the sur
rounding country. A desert waste of barren sand dunes
extended for many miles in every direction about the
present site of Arcachon, until the French Government,
some fifty years ago, conceived the project of planting
these dunes with pine forests, as a means of immobiliz-
ing the sand which, driven by the fury of the Atlantic
waves, was continually encroaching more and more upon
the country, the interior. A thick forest of these trees
(Pinus maritima) now covers an expanse of the coun
try, and by these pine-covered sand hilfs the site selected
(in 1854) for the now well-known sea-coast resort of
Arcachon is shut in and protected on every side except
upon the north, which is occupied by the great salt-
water lake above mentioned, upon whose southern shore
the town is built.

[There are nine thousand acres of these pine trees,
which produce a most peculiar stillness—owing to the
deep sand roads and walks not giving any sound, and
the pine trees having no leaves to rustle. — E. O. O.]

From its close proximity to the Atlantic Ocean, Arca-
chon necessarily possesses a climate characterized by
the moderate moisture of atmosphere, and by the equability
of temperature proper to most maritime stations. The
direction of the prevailing winds, which in this region
blow from the ocean, is an important factor insuring to
this sea coast station its proper maritime climate. From
the direct violence of the Atlantic gales, as well as from
the winds blowing from the east and south, Arcachon
is sheltered by the dense pine forest which envelopes
the surrounding sand dunes; while the sandy nature of its
soil serves in some measure to diminish the tendency to
excessive atmospheric humidity which might, perhaps, be
expected to exist in a region thus exposed to ocean
winds.

Winds blowing from the north and from the northeast
reach Arcachon after passing over its great lake or land-
locked bay, the circumference of which is stated by Dr.
J. Bennet to be sixty miles in length. These north and
northeast winds, therefore, "become some
what warmed in winter, and their irritating dryness
diminished, while it is maintained that they also bring
from the surface of this unusually salt sea water, and
of excessive emanations, to give a special efficacy to the air in certain
scrofulous conditions " (Health Resorts and Their Uses,
by J. Barney Yeo, M.D., p 261). According to the
author just quoted, the prevailing wind at Arcachon,
namely, the sea winds blowing from the northwest, west,
and southwest, occur most frequently from December to
February, "usually blow continuously day and night for
several days in succession ... often blow with great
violence, and were it not for the presence of these tree
pine-trees ... would form a serious drawback to the
climate." The average number of rainy days in that
portion of France in which Arcachon is situated is stated
by Lombard to be one hundred and thirty, while the
total amount of rain falling per annum is 2,736.8
inches, a greater part of which falls during the winter
and autumn months than during the spring and summer
seasons.

The mean temperature for the year at Arcachon is
59° F. the mean temperature of the winter season 46.4°
F., to 50° F. (Lombard). At Bordeaux the mean winter
temperature (according to the same author) is 43.7°F.
and the mean annual temperature is 65.6°. A very
pronounced difference of temperature between these two
points is thus made manifest despite the trifling differ-
ence in latitude existing between them. According
to data quoted from Dr. G. Hameau in the "Dictionnaire
Usual des Sciences Médecines," the result of a series
of thermometric observations taken at the town of
Arcachon, and covering a period of ten years, showed
the mean annual temperature at 8 A.M. to be 55.76°
F., and at noon to be 59.96° F.; for the minimum tempe-
raturns the mean annual was found to be 46.94° F.; for
the maximum thermometer on the 12th of July was 101° F.
Arcachon is both a summer and a winter resort, and
there are two distinct portions of the town, the one,
adapted for residence during the warmer months, lying
directly on the shore of the salt-water lake or basin, and
possessing facilities for bathing; the other lying away
from the water in the midst of the pine forest, separated
from the shore town by a high sand dune, and consist-
ing of "numerous villa residences actually built in the
forest, each house being surrounded by pine trees "(Dr.
J. Barney Yeo, op. cit.). This latter section is known as
the Ville d'Hiver, or winter town, while the former is
called the Plage, or beach. Of this Plage, Dr. Yeo re-
marks that it "is occupied by somewhat closely packed
houses and buildings, and becomes in summer a sort
of Margate for the population of Bordeaux." Dr. J. H.
Bennet says of Arcachon that it is "a pretty sea-side town
. . . with good hotels, picturesque villas, convenient
and handsome club house and baths—indeed, all the
appurtenances of advanced civilization. The summer
town is built on the sandy shore of the great lake or sea,
which affords excellent bathing. The lake itself, from
its great extent and from its being landlocked on every
side, offers every possible facility for safe boating,
vagboarding, and fishing." After describing the Ville
d'Hiver and giving much other interesting information
concerning Arcachon in his entertaining book, "Winter
Cestodes.
may happen, there be no benefit for the first two or three days; and especially should doses be taken on the empty stomach early in the morning and late at night.*

Edward Curtis.

CERVICAL FISTULA. See Teratology.

CERVO- BRACHIAL NEURALgia. See Neuralgia.

CERVO- OCCIPITAL NEURALgia. See Neuralgia.

CestoDAta.—The branch or Phylum Platyhelminthes, commonly known as the Flat Worms, is characterized by a bilaterally symmetrical body somewhat flattened dorso-ventrally and usually elongate, by the mass of parenchymatous tissue which fills all the spaces of the body, by the absence of any true body cavity, by a protonephridial excretory system, and by the complicated sexual apparatus which with rare exceptions is hermaphroditic, and which produces so called compound eggs. Among the most prominent orders of the branch are the Trematoda or Flukes (q. e.) and the Cestoda or Tapeworms to be considered here.

The order Cestoda includes a large number of forms which manifest considerable differences in anatomical detail, but are comparatively uniform in general appearance and structure. The small group of Cestodaria, or Monozoa, which differ from all others in possessing but a single set of reproductive organs, and consequently but a single segment in the body, is included by some investigators in the order under consideration, but by others placed intermediate between the trematodes and the cestodes, forming as it undoubtedly does a group transitional from the one order to the other. The species of Cestodaria are, however, rare and infest the lower animals, so that they will not be discussed here.

In the Cestoda a, str., the body is characteristically ribbon-like and divided into "links," or proglottides. In most cases, including all the tapeworms of man, the segmentation is evident externally. At the posterior end of the chain the proglottides are larger and more distinct, and often so loosely attached as to separate from the series under the slightest disturbance. The longitudinal separation takes place normally as the segments become ripe. Toward the outer end of the chain the proglottides grow gradually smaller and less distinct until near the anterior end it is usual to find a short region, the neck, in which no trace of segmentation is visible. The anterior end has the form of a bulbous swelling, known as the head or scolex (Fig. 1205), on which are borne the organs of fixation. The latter are either suckers, hooks, or both, and these suckers may be either elongate grooves or bothridia, cup-shaped hollows, or acetabula, or, as in some marine tapeworms, of a folded form which is much more complicated.

At the apex of the head is found in the Tenidace a muscular organ, the rostellum which bears the hooks, usually in one or more annular rows. In form and degree of development the rostellum is a very variable organ; at the one extreme in *Timia saginata* it is reduced to a small muscular sucking apparatus, often spoken of as the apical or fifth sucker of that species, while in other forms it is powerfully developed and capable of extension or retraction into a pocket at the apex of the scolex.

It is a valuable feature in the distinction of various species.

In the head one finds the central nervous system in the form of a bilateral ganglionic mass with one or two ring-like commissures from which nerves are given off directly to the suckers and rostellum, and from which the longitudinal nerve trunks pass backward throughout the length of the chain. Three of these trunks, the main lateral nerve (Fig. 1204, *ln*), and two minor (*ln*') are grouped together on each side of the proglottis, while the two dorsal and the two ventral longitudinal nerves (*ln*') are located nearer the median line. The various longitudinal trunks are connected by commissures which at stated intervals pass around the proglottis; they also give off branches by which the various organs are innervated.

Near the lateral nerve trunks are located the main longitudinal canals (*l.*c.) of the excretory system which originate in an irregular network in the head and from which are given off numerous branches often in the form of a network of fine vessels in each proglottis. In many forms a prominent transverse canal near the posterior margin of each proglottis joins the longitudinal canals (cf. Fig. 1205, *O*). Terminating the finer canals of this system are found the characteristic flame cells which are peculiar to this type of excretory system.

A cross section of a proglottis (Fig. 1204) shows the various layers of which it is composed. Externally the cuticula, a resistant factaceous excretory envelope, is a dense tissue layer, and is reflected a short distance inward at the various external orifices. The other view, by virtue of which an epithelium is wanting in cestodes and the outer layer represents a basement membrane, has been definitely set aside by the recent investigations of Blochmann. The cuticula is really the product of the subcuticular cells, though they are apparently separated from it by a considerable interval. Immediately beneath it occurs a delicate double layer of dermal muscles, having externally circular, and internally longitudinal fibers, the two systems of which lie deeper in the body. Between these fibers the bases of the subcuticular cells extend from the cuticula to the deeper lying bodies of the cells; the remaining space of the body between the various organs is filled with parenchymatous tissue. Within the parenchyma (Fig. 1205, *G*), Terminating the finer canals of this system are found the characteristic flame cells which are peculiar to this type of excretory system.

The anterior end is divided by the parenchymal or body musculature into two regions, an external cortical layer and the median area or medullary region. In the latter are found most of the reproductive organs, although in the Bothriocephalideae the vitellaria lie in the cortical layer. The body muscles are of three sets, longitudinal, transverse, and dorso-ventral or sagittal. The longitudinal

*Fig. 1205.—Transsection of Proglottis of *Timia solium*, somewhat diagrammatic. *ln.*, Main lateral nerve; *ln'*, accessory lateral nerve; *ln"*, ventral longitudinal nerve; *l.*c., longitudinal canal; *ln'*, body nerve; *l.*c., lateral body muscles; *l.*e., elongate, muscles. The section is represented as having cut one of the ring commissures throughout nearly its entire extent. (Original.)

*Fig. 1263.—Anterior End of *Timia solium*, Showing Suckers, Rostellum, Suckers, Rostellum, with Hooks, and Neck. × 55.*
The muscles (Fig. 1204, \( m l \)) form the outer layer of the muscular mass broken only at the sexual pore, and though variable in amount are always numerous. The transverse muscles \(( c c \), often called circular, constitute a plate just within the longitudinal fibres; at the side these fibres intersect and spread through the longitudinal muscles like the rays of a fan. The sagittal fibres extend singly or in small bundles from dorsal to ventral surfaces directly through the proglottids; they are scattered and not so numerous as the other systems of fibres.

Absolutely no trace of an alimentary tract has yet been discovered in the cestodes. Imbition is the only known method of taking food, and the adult tapeworms are acell.

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<th>vsl.</th>
<th>skpl.</th>
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<td>vag.</td>
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The transverse commissure of excretory canals; Cl, genital cloaca; D.st., vitellaria; H, testicular follicles; X, lateral nerve trunk; Or, ovary; Ut, uterus; W, longitudinal excretory canal. \( \times 10. \)

The gills unite with their posterior ends in the rectum, where they open into the cloaca. They consist of a single large, racemose gland (D.st., Fig. 1205), or a multitude of small follicles (vit., Fig. 1206) in which are produced the masses of yolk material to be included in the eggs. Vitelline duct and ovicord join the continuation of the vaginal canal in the shell gland, and to this portion of the duct the name ootype has been given. Here the ovum coming from the ovary is fertilized by the spermatozoon from the seminal receptacle, is surrounded by a mass of yolk material from the vitellaria, and the whole encased in a capsule formed by the secretion of the shell gland, which rapidly hardens into a thick chitinous shell. The completed eggs are then forced outward into the uterus. Since they consist not only of a fertilized ovum but also of a mass of disintegrated yolk cells, the name compound egg has been applied to them. Such eggs occur only in the flat worms.

The uteri may possess a special external opening or may be without such. In the latter case it is small at first, but with the accumulation of eggs it becomes irregularly enlarged by the formation of lateral outpocketings so as to occupy with its branching system the entire space of the proglottis (Fig. 1207). In the course of this transformation other organs gradually disappear until the ripe segment is little more than a muscular sac which encloses the branching uteri crowded with eggs. The manner of branching is characteristic of the species, as is also the way in which ripe proglottides are detached either singly or in groups, and both features together with other details in the structure of the reproductive system are discussed in connection with the individual species.

The eggs of the cestodes are oval and provided with a thin shell which is often supplied with a lid. Within this occurs in many eggs (Fig. 1208) a single, hard outer shell which encloses the embedded yolk cells. The latter are enclosed in a sac which has the structure characteristic for the family in which it occurs. In reality this inner structure is not a shell but an embryonic membrane, and takes its origin during the early growth of the germ cell, which occurs in most cases while the egg is still retained in the uterus of the adult cestode. When the uterine egg is examined soon after its formation, the shell is seen to contain a single germ cell surrounded by a number of yolk cells which, in some cases, have lost their cellular identity and constitute merely a mass of granular yolk substance.
The embryo originates from the development of the egg cell alone while the yolk cells serve as nutrient during its early growth. From the division of the egg cell, which undergoes total cleavage, there arises a spherical embryo surrounded by one or more embryonic membranes. From the latter may originate an inner shell, as in Taenia (Fig. 1208), or a ciliated mantle, as in Bothriocephalidae (Fig. 1209). The spherical embryo (Fig. 1210), which is known as the onchosphere, is uniformly characterized by the presence of three pairs of hooks of variable shape and by great mobility, and in this condition is ready for introduction into the secondary host. This may be the result of a direct migration, or when the cysticercus embryo, swimming about in the water, is swallowed by a suitable host; or it may be of passive character, as when the tenial egg containing an embryo enveloped in its membranes arrives by chance in the alimentary canal of the larval host; in the latter case, at least, it is necessary that the eggs should be introduced into the stomach and be subjected to the action of the gastric juice to disintegrate the shell and membrane. Were this not so it is clear that the harboring of the adult in the intestine would be, in these cases in which the larva parasitizes in the same animal, a source of extensive secondary infection. In such cases it is well known, as for instance in Taenia solium of man, that any reversal of the ordinary perisohal action of the shell, which brings loose proglottides into the stomach and subjects them to gastric digestion, will result in the release of the six-hooked onchospheres, and in the infection of the host with the larva. Once that the membranes are broken down and the onchosphere is set free they bore their way actively, by virtue of the hooks, through the wall, probably in most cases of the proximal portion of the intestine, and are believed to be distributed further by virtue of the portal circulation; at least the liver and the connective tissue adjacent to it are the chief seats of the larvae. Having come to rest at such a point the embryo throws off its hooks and forms on its surface a thick cuticular layer beneath which are differentiated the muscle fibres, while about each embryo is formed a cyst by the activity of the host. The centre of the sphere is filled at first with a loose parenchymatous tissue in which soon appear irregular spaces that later fuse to form a large central cavity. Thus has been reached the first form of the larval stage known as the bladder worm or cysticercus (Fig. 1211). A growth of two to four weeks ensues in which the parasite reaches, with the connective tissue to the diameter of a millimeter, when the second stage in the development is entered upon by the appearance of a mesenchymal proliferation of cells at some point on the bladder; into this projection there penetrates from the exterior a hollow cylindrical ingrowth of the cuticula (Fig. 1211) forming the starting-point of the scolex of the adult worm. As the growth becomes larger the ingrowth presents the form of a flask (Fig. 1212, J); it is still covered through

out by a cuticular layer, and at the base of the flask there arise in reverse the structures which characterize the head of the tapeworm; at the centre the rostellum with its crown of hooks, and on the sides the suckers lying, when fully developed, the characteristic form and size (Fig. 1212, B) of the adult.

Under proper conditions the head begins to be everted, starting from the base and continuing until, with the neck, it ultimately projects above the surface of the bladder (Fig. 1213). This process may at times take place while the bladder worm is still retained within its host's crown of hooks, and on the sides the suckers lying, having been accompanied by the appearance of the first proglottides (Fig. 1214, B). The scolex system of excretory canals originates early (Fig. 1208) even before the suckers and rostellum have appeared, and persist unchanged in the scolex of the fully developed adult.

In the formation of the proglottides it may be noted that the terminal proglottis is the oldest, and that new segments are continually formed in the vicinity of the neck. The sexual organs appear early as strings or masses of embryonic cells in the midst of the parenchymatous tissue; formation of proglottides and growth proceed so rapidly that the tapeworm has matured and set free the posterior joints in a brief period. These reach the exterior with the facial matter, often manifesting great independence and power in movement. They contain masses of eggs stored up in the uterus with which the beginning of the life cycle is again reached.

The normal seat of the tapeworm is in the alimentary canal, and usually in the small intestine where the worm lies close to the wall with its head more or less embedded in the villi. Occasionally one of the smaller species wanders from this place into the ductus choledochus, and more rarely into the liver itself. This seems to be the normal habit of a few species not found in man. The occurrence of tapeworms in the human stomach or anterior intestine, as reported by various medical observers, is due either to a post-mortem wandering or to regurgitation. On the other hand the reported occurrence of Cestoda in the bladder, and the discharge of proglottides from the
urethra, can be explained, in so far as the cases do not rest on erroneous observations, only on the basis of injury or accidental introduction. Portions of a tapeworm have been at times discharged from abscesses or fistulae which have probably laid at some time a connection with the intestine. Leddy's discovery of a specimen in a cucumber admits, however, of no such natural explanation. Though often torpid when examined after discharge, the worm is under no circumstances in a quiescent condition or motionless. The fluid contain- ing the parasite, which is usually excreted on the first admission of the patient to the hospital, is active; it moves with a free, graceful, reciprocal motion, and is seen to pass gradu- ally through a series of stages in its course. The fluid contains a white, inelastic, thread-like substance, and is often tinged with a greenish tinge. The adult tapeworm is not seldom found in the mesentery, active in its warm, blooded host. To its contractions are due the serious symptoms which often accompany its presence. Even the discharged proglottides live for several days outside the host under ordinary circumstances. No other form of parasitic infection shows two such symptoms of indigeni- ty in the patient, as this form. By its virtue of this apparent completeness and activity, the separate proglottides are frequently diagnosed as flukes.

The effect of the parasite on its host may be regarded first from the standpoint of loss of nutrition. This has been carefully computed by Leuckart for the largest human tapeworms, and amounts in one year for a single specimen of Dibothriocephalus latum to 500 from 700 gm, and for Taenia saginata to 1,500 to 2,000 gm. Although the presence of a number of individuals may heighten this materially, yet the amount is entirely insuffi- cient to explain the far-reaching effects which are manifested by man as the result of the presence of only a single one of these parasites. The two severe symptoms are noticeable in a nervous character. Anemia is a frequent manifestation, and this displays at times a pernicious tendency which in one case at least has terminated fatally. Many of the symptoms affecting individuals who harbor tapeworms have been attributed to poisons developed and excreted by the parasite within the body of the host. Not only is this evinced by the subsidence of the nervous and epileptic symptoms on the removal of the tapeworms, but the affections of the eyes so frequent in those afflicted naturally be due to the effects of a poison absorbed from the intestine and circulating in the blood. The fluid extracted from a hydatid cyst has been shown by experiment on man and animals to be toxic. To this quality may doubtless be attributed the severe symptoms or even death consequent upon the rupture of such a cyst or its operative puncture. An extract from Diboth- ricocephalus latum has been shown to exert a globulicalid effect on dogs, and one of Taenia saginata has been found to kill tubercular bacilli. The symptoms of tapeworm disease are by no means well defined and may include almost any possible com- bination. In experimenting upon himself, however, Stiles noted during the presence of Taenia saginata as the most constant symptom one not heretofore recorded. He says, during the time of my infestation frequently happen as I walked along the street or across the room that I suddenly felt a peculiar sensation almost exactly similar to the sensation one feels upon the sudden descent of an elevator. Despite the indelibility of the clinical aspect of tapeworm infection, any suspicions of such trouble may be definitely tested by a microscopical investigation of the feces. The presence of adult cesto- todes will be manifested by an abundance of their char- acteristic eggs.

The specifics which are most frequently employed in driving out tapeworms are Cortex granati, of which the effective principle is an alkaloid known as "pellterine." Flores Kosso containing the amorphous kosotoline, Rinne's tablets containing the amorphous alkaloid and kanala with the resinous kanala (see Anthelmintics). In bringing about the evacuation of the parasite some precautions are necessary to insure success. When a patient is passing a tapeworm the parasite sometimes buries itself in two spots to the transition from the warm bowels to the cold air or to a cold porcelain vessel. By the use of a vessel containing warm water this sudden change and its consequent evil effects may be avoided. In the next place cestodes are frequently expelled in a knotted mass, and may obstruction in the lower portion of the canal may delay their passage sufficiently to permit the parasite to secure a new hold on the wall. Conse- quently success may depend upon thoroughly clearing out the canal.

The distribution of each species will be considered under its proper heading; here, however, some general items may be noted concerning the frequency of tapeworms. Stiles gives the following table of:

### CASES OF TAPEWORM IN MAN

<table>
<thead>
<tr>
<th>Authority</th>
<th>Country</th>
<th>Dates of records</th>
<th>Total number of cases</th>
<th>Total number of cases reported</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parona</td>
<td>Milan</td>
<td>1869-97</td>
<td>163</td>
<td>Total of 1,963</td>
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<tr>
<td>Parona</td>
<td>Milan</td>
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<td>163</td>
<td>Total of 1,963</td>
</tr>
<tr>
<td>Krabbe</td>
<td>Denmark</td>
<td>1889-95</td>
<td>200</td>
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</tr>
<tr>
<td>Krabbe</td>
<td>Denmark</td>
<td>1889-95</td>
<td>200</td>
<td>Total of 1,963</td>
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<tr>
<td>Stiles</td>
<td>U. S. A.</td>
<td>1869-97</td>
<td>163</td>
<td>Total of 1,963</td>
</tr>
<tr>
<td>Stiles</td>
<td>U. S. A.</td>
<td>1869-97</td>
<td>163</td>
<td>Total of 1,963</td>
</tr>
</tbody>
</table>

**Sex of Patients**

<table>
<thead>
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<th>Female</th>
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<tbody>
<tr>
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<td>562</td>
<td>601</td>
</tr>
<tr>
<td>Parona</td>
<td>1,963</td>
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<tr>
<td>Krabbe</td>
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<td>Krabbe</td>
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<tr>
<td>Stiles</td>
<td>1,963</td>
<td>562</td>
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</tbody>
</table>

*Children.*

He attributes the evident sex difference merely to the fact that women ordinarily prepare the human body and are hence more exposed to chance infection than men. Statistics of French military hospitals give for the period 1886-90 about 1.5 per cent, of cases for tapeworm infec- tion, and records of the United States hospital service during the war contain a total of 0.92 per cent, and treated for tapeworms. This percentage is under the circumstances naturally abnormally low as compared with conditions in times of peace.

The occurrence of various species in different regions may be adjudged from the following table. Such figures exist only for a very few localities:

- Cestodes have been known from the earliest times, and both tapeworms and bladder worms are distinctly recognized in the oldest medical works which have come down to us. One of the hermetic books of the Egyptians, that on medicinal use and writing, attributed to the physicians of Ebers, dated about 1550 B.C., gives in hieratic writing extensive sections on these parasites and their treatment, which are taken in part from the writings of earlier physicians. The proscription placed by Moses on the use of certain flesh has its undoubted ground in the abundant presence in such animals of bladder worms. Hippocrates notes the presence of echinococcus bladders in man and an operative method for removing them. He also speaks of the evacuation of fragments like pumpkin seeds as diag- nastic of the tapeworm. Both he and Aristotle speak of the bladder worm of the pig as well known, and advise the detection of its presence by examining the lower sur- face of the pig's tongue where the cysticerci appear as swellings. This method is followed even to-day. Aris- totle showed also that the tapeworm in contrast with the free round worms of the intestine was attached to the wall of the canal. Pliny adds to the accounts of his predecessors which he quotes only fabulous reports of the length of tapeworms (up to three hundred feet) and erroneous observations on their presence in cold springs. Galen mentions bladder worms from the abdomen of slaughtered animals and notes the tendency of the liver to "produce" these forms in its surrounding fascia.

It was 1869 A.D., however, before even two species were differentiated among human tapeworms, and 1700
REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

Cestoda, Cestoda.

Ripe proglottides trapezoidal, 0.75 mm. long by 2.5 mm. wide. (bb.) Genital pores on both margins of each proglottis; genital organs also double.

Ripe proglottides elliptical. Dipylidium caninum.

(B.) Genital organs single in each proglottis. Head elongated oval; length of worm 2 to 7 meters. Ripe proglottides 2 to 4 mm. long by 10 to 12 mm. wide. Diplobothrium latum.

Head short, coniform; length of worm barely over 1 meter. Ripe proglottides approximately 5 to 6 mm. square. Diplobothrium cordatum.

In all cases reference should be made to the fuller descriptions given for each species in the text, and thus the results obtained by use of the brief criteria contained in the key controlled. Special attention should be paid to those species which are as yet incompletely known; the writer will be glad to assist in the identification of any such.

The Cyclophyllidea possess a scolex with four circular suckers, often with an apical rostellum on which hooks are found when present. Segmentation is pronounced and the ripe proglottides do not separate until fully developed. There is no uterine aperture and the common sexual pore is located on the margin of the proglottides. The eggs are thin-shelled and without a cover. The adults live in the alimentary canal of the higher vertebrates. The order contains but a single family, the Tenui-idea.

For the genus Tenuia the following characteristics are diagnostic. Large species with ripe proglottides much longer than broad. Uterus with median trunk and subsequently formed lateral branches during the development of which the remaining sexual organs disappear. Cysticercus, larva, or cestodes, found in herbivorous mammals and also in man; adult in man and the carabidous mammals.


Length 4 to 8 meters or even to 74 meters (Borchardt-Pyramid). Head (Fig. 1215) somewhat four-sided, 1.3 to 2 mm. in diameter, without rostellum and circle of hooks but with a sucker-like depression in its place which is often pigmented. Neck long, narrower than head. Proglottides number more than 1,000 and increase gradually in length until the ripe segments of characteristic pumpkin-seed appearance measure 16 to 20 mm. long by 4 to 7 mm. broad. Genital pores irregularly alternating, marginal, and posterior to the centre of the proglottis. Uterus in ripe proglottis with median sten and twenty to thirty-five slender lateral branches, themselves often branched. Egg shell delicate with one or two polar filaments (Fig. 1216). Embryophore ovoidal 35 to 40 μ in diameter. Adult exclusively in small intestine of man; larva (Cysticercus bovis) in the muscles and viscera of cattle.

Structure.—The arrangement of the reproductive organs in a sexually mature proglottis (Fig. 1205) is best

*Only the synonyms most frequently met are given under each species.
visible in a segment taken about 40 to 50 cm. from the head. The general structure of these organs has been described above. Characteristic for this species are the two ovaries of unequal size, that at the pore side being the smaller and without the long stalk in the ovotestis. They are discharged off by the vagina in as T. solium. The whole proglottis has a more open aspect, and the various organs show relatively greater antero-posterior diameter than in T. solium. The uterus in the ripe proglottis (Fig. 1207) manifests a more crowded structure in the lateral branches are slenderer and more numerous, and two or three are stunted or lacking opposite the sexual pore.

Development.—In 1861 Leuckart fed ripe proglottides of this species to calves and succeeded in obtaining the then unknown enfecuum, although various facts had pointed out cattle as the probable intermediate host. These results have been confirmed by many other investigators. At six weeks the size of the cysticercus (Fig. 1211), shelled out from its cyst, is: length 6 mm., breadth 5 mm., diameter of the head 1 mm.; at two weeks corresponding measurements are 4, 4, 1.8 mm. (length of head); at twenty-four weeks, 6, 4, 2.2 mm.; at forty-eight weeks 7, 5, 2.5 mm. The length of life of the cysticercus is brief; at least less than three months has been found completely calcified. A temperature of 47° to 48° C. is always fatal. Of course the internal portions of roasting pieces are often far from reaching this temperature. On the other hand exposure to cold-storage conditions for three months is sufficient to destroy all these cysticerci contained in a piece of beef.

Artificial infection of man with the adult by eating flesh containing living specimens of Oxyuris vermicularis has been with equal success. An average growth of 72 mm., or about thirteen to fourteen proglottides daily, was determined.

Anomalies.—T. saginata appears to be peculiarly subject to variation and malformation. Excessive pigmentation of the head and tail led to the establishment of the species T. vermicularis by various authors and expulsed by a Frenchman who had lived for some time in the United States. Two genital pores, on the same or opposite margins of the proglottis, but each connected with a set of reproductive organs, indicates the probable dissection of the segmental boundaries, and this may be manifested over a considerable stretch of the worm, giving the appearance of an unsegmented body. Welch has observed such an unsegmented region 5 cm. in length. Intercalated proglottides or roughly triangular joints are not uncommon. A common malformation consists in the perforation of a series of proglottides. This anomaly has received a specific name, T. fenestrata, at the head.

The fenestration appears first at the centre of the proglottis and becomes more accentuated toward the posterior end of the chain. Its cause is not understood.

Finally there occurs a prismatic or trinodal variety (Fig. 1217) which was described by Bremer as the result of the fusion of two individual proglottides. The proglottis is Y-shaped in cross section, and the scolex bears six acutabula. Specimens of this sort were named T. corporens by Kiichenmeister and T. tahupone by Cobbold.

Oophorones of T. saginata have been observed of considerable size, and armed with from twelve to twenty-two hooks; and Cobbold has described specimens of Oxyuris vermicularis from the heart of a calf with only three, two, one, and even no suckers on the head.

The form described by Weinland as T. solium var. abietina, from a specimen collected by Ag. Zeit in Chippewa Indian, is regarded by many as a small specimen of T. solium with unusually dense and delicate branches of the uterus (Fig. 1218).

Distribution.—The adult occurs only in man and is confined to regions where the Oesophagostomum is recorded in writings of great antiquity: in Africa, Europe, and America. It is also abundant, and its frequency has increased during recent years, whereas the contrary is true of T. solium. The evidences that this species occurs in the custom of eating beef are well known. Beef is rare, but pork well done. The figures given by Bœrger-Féraud for French maritime hospitals during the six quinquennial periods from 1861 to 1880 show a serious and relative decrease of cases from 0.2 to 14.8 per mile. In Paris the increase, though real, was much less, being from 0.3 to 0.6 per cent. in the same time.

The larval form, C. bovis, has been produced experimentally in rare instances in other hosts, sheep and goat, but many experiments on these and other animals have been made without success. In its normal host (cattle) the bladder worm was apparently rare, even in regions where T. saginata occurred abundantly. This apparent contradiction has been explained by the demonstration that in these cases normal fixation is often less perfect than in cases of diagnosis now that was formerly known.

The first mentioned number of cases of T. solium in man are on record. They include cases from the brain and eye, and the determination of the species rests on the absence of hooks and rostellar. Since, however, these organs may be wanting in C. bovis, the larvae of T. solium found in instances of diagnosis still require confirmation. In the cases under discussion must be viewed with suspicion.

Pathology.—Most common in hosts between twenty and forty years of age, the beef tapeworm has been encountered in the aged and even in newborn infants. Its normal place of fixation is near the pylorus, where the head is firmly fastened to the mucosa by its suckers. It may, however, be found exceptionally in the stomach. Symptoms of its presence are direct and local in the digestive system, or nervous and reflex in character. The latter are more common but may be present without causing symptoms. In the cases described a case in which this species, in spite of its lack of hooks, had bored through the wall of the duodenum and some distance in a circuitous course into the pancreas. In this case there were worms of one observer, who described the worm could have made use, while other evidence supported the view of active burrowing on its part. Possibly the rare cases in which tapeworms have made their exit through the navel or bladder may be susceptible of a similar explanation. This is, however, the only case on record which has been subjected to a thorough scientific investigation.

The proglottides of this species are expelled spontaneously and in the interval between stools. The movements after excretion are frequent and continued as is evidenced by the discovery of segments high on the wall of the duodenum or omentum. The anterior margin is lacerated by separation from the chain, and in crawling the proglottides distributes eggs from the uterine branches. Necromon detached segments are frequently digested as flukes, a conclusion apparently strongly confirmed by their independent activity.

This species cannot be regarded as equally dangerous with T. solium since here there is no chance for auto-infection by the oophorones. The disturbances attending its presence in the alimentary canal, however, are such as to call for its removal. Despite the absence of hooks in the species tuxa is, as a rule, more difficult of accomplishment than in the case of the pork tapeworm. The removal of the body weight, in young and neck constitutes
but a temporary relief since a new chain is produced in a short time.

_T. tenia africana_ v. Linstow 1900.—Length 1.4 mm.

ters, greatest breadth 13 to 15 mm. Scolex unarmed, no-
tably small, 1.4 mm. wide by 0.5 mm. long. Proglottides
number about 600, decidedly broader than long; ripe
proglottides measure 7 mm. long by 12 to 15 mm. broad.
_Uterus_ (Fig. 1219) with fifteen to twenty-four simple
branches radiating from median trunk. Eggs thick
shelled, 31 to 34 μ in diameter. Adult parasitic in natives of German East
Africa; development unknown.

This species, only recently described, was obtained
from black soldiers near Lake Nyassa in Africa. It
differs radically from the common unarmed tapeworm of
man, as is evident from examination of the sexually ma-
ture proglottis (Fig. 1220). Of importance in consider-
ing its development is the report that these natives are
accustomed to eat the flesh of the _zebu_ ram.

_T. vulgaria_ Werner 1789, _T. solium_ Rud. 1819. Length 2
to 3 mmeters, rarely 6 to 8 mmeters. Head (Fig. 1209) spherical
0.6–0.8 mm. in diameter. Rostrum short, often pig-
mented, with a double crown of twenty-four to thirty-
two hooks in which large and small alternate regularly
(Fig. 1321). Large hooks 0.16 to 0.18 mm. long, smaller
0.11 to 0.14 mm. long. Neck long and slender. Proglot-
tides eight hundred to nine hundred in number, at 1
meter from the head square with sexual or-
gans fully developed; at end of chain when ripe, 10–12 mm. long, 5–6 mm.
broad. _Uterus_ with prominent median stem and on each side seven
to ten heavy branched lateral outpocketings. Embyrophores 31–36 μ
in diameter. Adult in small intestine of man; larva (_Cysticercus cell-
llosus_) in muscles and viscera of domestic pig, rarely also of dog, man,
and ape.

Structure.—In general appearance the pork tapeworm is distinctly more delicate
and its chain less muscular than the beef tapeworm, pre-
viously described, and all its measurements display this
difference. The scolex is decidedly smaller and has a
prominent rostellum with two rows of hooks. The points of the hooks lie in a circle, but since they alternate regu-
larly in size, the bases form two concentric circles. The
hooks of the two sets show characteristic differences in
figure (Fig. 1222) as well as in size.

The sexually mature proglottides do not exceed 4.5 to 5
mm. in width by 2.5 to 3 mm. in length, being thus de-
cidedly inferior in size to those of _T. saginata_. On ex-
amination one sees the same organs in much the same re-
lation as in the beef tapeworm; but there are minor dif-
fences which serve to distinguish the two species. Most prominent is the unequal size of the two ovaries (Fig. 1223), the one next the genital pore being the smaller and being oval in outline rather than circular. In addition a small ovarian lobes lies in the angle between the vagina and the uterus, as if cut off
by the former canal from the ovary to which it apparently
belongs. This accessory lobe is a constant and
reliable peculiarity of the pork tapeworm.

One may notice also the generally com-
pressed form of the various organs most
marked in the flattened _vitellarium_ near the posterior edge of the proglot-
tis.

The differences between the two species are less evident from
examination of the ripe proglottides. Usually the segments
of the pork tapeworm are given off in sets of two or
three rather than singly. The individual proglottis is
thinner, less muscular, in general also smaller and more
transparent; yet these are highly variable features and
often deceptive. The form of the uterus, however, gives
to the proglottis a characteristic appearance. There are
only seven to ten lateral branches which are more heavily
and unevenly branched, while the ends of the branches
are not infrequently enlarged (Fig. 1324).

Development.—The eggs (Fig. 1209) are oval, the outer
shell is thin without polar filaments and
transient; the inner shell is thick, radia-
tely striated, and spherical. The oacho-
sphere is also spherical, measuring 30 μ
in diameter. The development of the em-
bryo is slow; in eight days it had only
reached a size of 38 by 24 μ, and at the
end of three weeks its diameter was but
0.8 mm., while in thirty-two days differ-
cut individuals measured from 1 to 6
mm. by 0.7 to 2.5 μ. Even in the
smallest, however, a head projection
could be seen, and in the second month
suckers and hooks are formed while the
neck has grown so long as to produce one
and a half complete circles within the
bladder. By the close of the third
month the bladder worm is probably
ripe and capable of successful transfer-
cure.

The longevity of the _Cysticercus cell-
llosus_ is dependent upon various circum-
stances. Not infrequently it degener-
ates at an early period, but more often
later, by the loss of its liquid and by de-
position of lime, into a mere calcareous
granule. The same individual has, how-
ever, by means of the ophtalmoscopic,
been observed living in the eyc for twenty years. Free cysticercid live only a brief time in water, but in flesh at normal temperature they remain living up to twenty-nine days.

Many experiments have demonstrated that the Cysticercus cellulose of the pig, when introduced into the human alimentary canal, gives rise to Tena solium. From ten to twelve weeks are necessary for full development and for the expulsion of the ripe proglottides. Efforts to bring the cysticercus to development in other hosts than man have as yet failed.

Anomalies.—Though less frequent than T. saginata, many of the same malformations occur. Both incomplete and complete fusion of two or more segments and segmentation of parts of the chain are on record. An unusually slender structure of the chain gave rise to Cobbold's species, T. tenacis, sometimes regarded as a distinct variety even yet. A scolex bearing six hooks, longer and slenderer than that of that form and adapted to the space in which it lies. In some cases this variety is without a scolex or possesses at most but an abnormal rudiment of one.

Most interesting of all is the form which led to the establishment of a new species, Cysticercus acanthothrius, and by deduction a new tapeworm, Tenia acanthothrius. The Cysticercus acanthothrius was first observed by Weinland in 1858 at an autopsy of a white consumptive in Virginia. The bladder worms were in the dura mater, muscles, and subdural tissues. Though in size and form like C. cellulose, these hydatids (Fig. 1226) possessed three rows, each of fourteen to sixteen hooks, longer and slenderer than those of that form and measuring reasonably 153 to 196 µ, 114 to 140 µ, and 63 to 70 µ. The discovery in several cases of identical bladder worms in European countries and the improbability of the existence there of an unknown large tapeworm with three circles of hooks, together with the occurrence in one case at least of this peculiar form side by side with C. cellulose, have led most investigators to regard C. acanthothrius as merely a variety of the common pork bladder worm.

Cysticercus—Tena solium is a rare species. Though very rare in tropical lands, and wantings among such races as abstain from the use of pork. On the other hand, especially in those regions where the inhabitants are accustomed to eat the flesh of the pig in a poorly cooked condition, the parasite is most abundant. Certain provinces of continental nations come within these limits. Contrary to the statements of a number of standard authorities, I am confident from the evidence gathered that this species is very rare at present in the United States. Some figures have been adduced to show that it is becoming decidedly rarer in both France and Germany. In Denmark it was, in 1809, the commonest human cestode, being present in 53 out of 100 cases; in 1887–95 it was not found once in 100 cases (Krabbe).

Cysticercus cellulose is present not only in the pig but also in the wild boar, deer, dog, cat, rat, brown bear, ape, and even man himself. In the pig the bladder worm is more abundant in such animals as are allowed to range than in those that are stall fed. In Germany the ratio of infected animals varies in different provinces from 1 in 100 to 1 in 2,000 according to reports of meat inspectors. As these cover, however, only the cases in which the infection is prominent, the actual figures are much larger. Leuckart calculated some years ago that two to three pigs per hundred were infected. This bladder worm also seems to be growing rarer during recent years.

Pathology.—Tena solium lies with the head fastened in the anterior portion of the small intestine. The proglottides are passed in groups with fecal matter; exceptionally through alimentary communications they reach the body cavity, bladder, and abscesses, or finally are thrown out per os by vomiting. The troubles caused by the worm do not differ from those due to T. saginata, yet the former is a much more dangerous parasite since its bladder worm may also develop in man. When abundant the bladder worms produce in pork the conditions known as "measles," and mealy pork is the ordinary means of introducing T. solium into the human system. Rarely it may be caused by the consumption of the infected flesh of the wild pig or deer. Smoking and salting, unless extended and thorough, will not kill the bladder worms in pork and ham. Thorough cooking, however, renders them entirely harmless. As early as 1588 the cysticercid were observed in the dura mater of an epileptic. While the brain and eye are apparently the most frequent seats of the bladder worms, the latter occur also in the muscles, subdural tissue, heart, lung, liver, peritoneum, etc. Particularly dangerous are, of course, the cerebral cysticerci (Fig. 1229) which produce effects parallel to brain tumors. In this location they are not rarely the cause of sudden death. According to Verdun and Iversen the bladder worm of the cerebral vesicles is ordinarily free and not of the racemose variety. The acephalocystic vesicle is most common, next comes the simple form with a single head, and rarest are those consisting of a few vesicles united by the stalk. The fourth ventricle is the most frequent location of the parasite. The symptoms due to the presence of such cysticerci do not permit of certain diagnosis; in general are, however, signs of compression due to ventricular hydrocephaly.

Fig. 1225.—Brain Cysticercus. Fresh specimen opened to show internal structure. a, a', Suck of racemose body (scolex). × 3.

(After Kratter and Bömigi.)
The introduction of the onchochones into the human stomach, which is a necessary preliminary to further development in the system, is brought about by impure drinking-water, by the use of salads or uncooked vegetables contaminated by the embryophores, and by the careless use of unsanitary closets. More frequently, no doubt, the host of the adult tapeworm infects himself through lack of cleanliness in defecation, or possibly, as has been suggested, by internal auto-infection. Any circumstances which might lead to the passage of adult proglottides containing ripe onchochones from the intestine back into the stomach would result in infection by those onchochones which remained there a short time as if they had been introduced through the mouth.

The danger of internal or external auto-infection demands immediate action by the physician for the removal of the parasite under great care that all regurgitation should be prevented. The success of the operation must be confirmed by the discovery of the tapeworm head, and the parasite destroyed rather than merely thrown away.

TENIA CONFUSA Ward 1896.—This species, originally described by the writer and later studied in greater detail by one of his students (Guyer), was obtained in Lincoln, Neb. In general appearance it is much like the two species just described, but may be recognized at once by the extraordinary length of the ripe proglottides, some measuring as much as 35 mm. long by only 4 to 5 mm. of their ovary. In the ripe proglottides the median stem of the uterus bears fourteen to eighteen irregularly branching offshoots swollen at the end into irregular club-shaped masses. Of the approximately 270 segments of the proglottide three points of difference in structure between this and the common species, T. saginata and T. solium, as tabulated by Guyer, the most important are subjoined. Nothing is known of the life history of this species.

<table>
<thead>
<tr>
<th>T. saginata</th>
<th>T. solium</th>
<th>T. confusa</th>
</tr>
</thead>
<tbody>
<tr>
<td>Size of terminal proglottides.</td>
<td>12-19 mm. long by 5-6.5 mm. wide.</td>
<td>10-12 mm. long by 3-5 mm. wide.</td>
</tr>
<tr>
<td>Greatest breadth.</td>
<td>6.5 mm. long by 5-10 mm. wide.</td>
<td>4.5-5 mm. long by 3-4 mm. wide.</td>
</tr>
<tr>
<td>Length of proglottides.</td>
<td>35-40 mm.</td>
<td>20-30 mm.</td>
</tr>
<tr>
<td>Sexually mature proglottides measure.</td>
<td>2.5-3 mm. long, 4-10 mm. wide.</td>
<td>1.5-2 mm. long, 3-5 mm. wide.</td>
</tr>
<tr>
<td>Neck is.</td>
<td>Unguemented, abundant;</td>
<td>Unguemented, abundant;</td>
</tr>
<tr>
<td></td>
<td>to sparse; to 0.005 mm.</td>
<td>to sparse; to 0.005 mm.</td>
</tr>
<tr>
<td>Longitudinal trunks.</td>
<td>Dorsal to genital ducts.</td>
<td>Spinal to genital ducts.</td>
</tr>
<tr>
<td>Depth of genital cloaca.</td>
<td>0.25 mm.</td>
<td>0.20 mm.</td>
</tr>
<tr>
<td>Width of genital por.</td>
<td>1.0 mm.</td>
<td>0.8 mm.</td>
</tr>
<tr>
<td>Lateral branches of uterus.</td>
<td>20-30</td>
<td>10-15</td>
</tr>
<tr>
<td>Size and form of eggs.</td>
<td>0.05-0.06 mm. long, 0.03-0.04 mm. wide.</td>
<td>0.06-0.08 mm. long, 0.04-0.06 mm. wide.</td>
</tr>
<tr>
<td>Pyriform process.</td>
<td>Present.</td>
<td>In young proglottides.</td>
</tr>
</tbody>
</table>

Further information is needed regarding the frequency and distribution of this form, which though distinguishable on careful examination, has doubtless often been regarded as the common species—whence the name confusa. The single record of its presence in man, reported from Algeria, is undoubtedly an error in the determination of the species found. In its normal host it is common everywhere in Europe and America so far as the records stand at present.

TENIA CRASSICOLLIS Rud. 1810.—Length 0.15 to 0.6 meter. Head 1.7 mm. in diameter with a double crown of thirty-four to forty-eight hooks, the larger 250 to 250 μ long, the smaller 120 to 100 μ. Embryophores oval, 36-40 μ by 31-35 μ. Adult in small intestine of dog; larva (Cysticercus parvicolis) in peritoneum of rabbits.

Braun records after Krabbe that in Jutland chopped mice are consumed uncooked on bread as a popular medicament against consternis. Evidently the introduction of living larvae of this species into the human alimentary canal would be not only possible but probable under these circumstances.

TENIA MARINOZTA Batsch 1786.—Length 1.5 to 5 meters. Head reniform, 1 mm. in diameter. Hooks thirty to forty-four in a double row; the larger measure 180 to 220 μ in length, the smaller 110 to 160 μ. Ripe proglottides 10 to 14 mm. by 4 to 7 mm. Cylindrical with short main trunk and five to eight large branches on each side. Embryophores spherical, 31 to 36 μ in diameter.

The adult lives in the small intestine of dog and wolf; larva (Cysticercus tenuicolis) is found in the peritoneum of apes, ruminants, and pigs. Experiment has shown that the larva will not develop to the adult worm in the human alimentary canal. The larva has been reported.
REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

Twice as a human parasite; but the record of its presence in the liver of man in Iceland has been shown to be a mistake. Hodges also reported its occurrence in man in the United States; but Wyman, who examined the specimens, stated that the hooks resembled rather those of *Cysticercus celluloides*, while the size of the cyst and the number of hooks favored *C. tuneden*). Since the latter features are known to be much more variable than the former, it is probable that the determination is erroneous in this case also.

Since the most dangerous of all human parasites is a dog tapeworm, and since several other canine cestodes are either known to be found or suspected to be parasitic in man at some age or in some stage of life, the dog tapeworms are evidently most important for the physician from the sanitary point of view, quite apart from the fact that by virtue of their serious effects on other domestic animals these cestodes demand attention from an economic standpoint. A strict control should be exercised over the condition of the dog in every household where such a pet is found, and the removal of the army of stray curs should be urged in every community; for these vagrants are the very ones most likely, by virtue of their omnivorous habits, to become infected and, in consequence of their nomadic life, to carry parasites from place to place.

The presence of tapeworms in dogs may be recognized by the proglottides found in the faeces, and I have known of such having been taken from the back of a dog and submitted to a physician as a curiosity! Manifestation of an anal or subcaudal pruritus on the part of the dog is also good evidence of their presence. In all such cases the health of the family demands that the physician insist on the treatment of the dog for their removal.

As the determination of the species may be of importance in such cases there is appended a table, modified from Neumann, of the canine cestodes thus far reported.

to suckling pigs. The development proceeds so slowly that in one month there has been formed a spherical solid only 0.25 to 0.52 mm. in diameter enclosed in a connective-tissue cyst formed by the host, the entire mass making nodules in the liver barely 1 mm. in diameter. At two months the larvae are twice as large, the wall consists of a thick external lamellar cuticula and a delicate granular internal membrane enclosing a watery fluid. At five months the diameter of the parasite has become 10–12 mm., but no structure is yet visible in the interior. To the parasite in this condition, consisting of cuticula, parenchyma layer (endocyst), and fluid contents, the name *Echinococcus* has been applied by some authors, and frequently the organism makes no advance in structure beyond this condition. Normally, however, there appears a protuberance on the endocyst (Fig. 1390, a) which develops rapidly into a brood capsule (b) in which the parenchyma is external and the cuticular layer internal. According to the views of some investigators these may become detached from the back of the parasite when a cuticular layer is formed about small centres of detached parenchyma; as these grow they burst out from the wall, and if they fall within the mother cyst and continue their development within the cavity of the latter, the form known as an endogenous echinococcus is produced; this variety occurs most frequently in man, pig, and horse. If, on the other hand, the daughter cysts burst out from the wall of the mother cyst, their continued growth (p-i) outside gives rise to exogenous echinococci. Evidently a group of several distinct individuals may easily be confused with a group consisting of mother and daughter cysts. Further development may also give rise to a third generation of cysts inside the second (l). Any or all capsules may remain sterile, i.e., without heads, and such are the echinocystic forms noted above. In most cases, however, heads are formed on the brood capsules or on the secondary cysts. According to the recent investigations of Goldschmidt a proliferation of the parenchyma layer in a brood capsule forms a new elevation (n) which grows there arises inside the capsule an annular furrow, and this growing outward cuts off a pyramidal elevation (n) which by virtue of its early developed muscles displays great mobility, hanging outward from the brood capsule (o) or thrusting itself into the same as a solid linguiform structure (p). The external chitinous cover-
ing of the fully formed head takes its origin in a second annular furrow outside the first, which gradually surrounds the parts already described (q) and on its completion leaves the head, projecting into the cavity of the brood capsule. Suckers and hooks originate and the entire structure presents the form of an inverted scolex. 

Fig. 1230.—Diagrammatic Representation of Echinococcus Seen in Section. a, Origin of a brood capsule; b, c, d, further stages in its development; e, fully developed brood capsule; f, endogenous daughter cyst formed from brood capsule; g, origin of an exogenous daughter cyst; h, i, j, k, its further development; l, an exogenous daughter cyst forming an exogenous and an endogenous cyst of the third generation; m, origin of a scolex as a minute elevation in the wall of a brood capsule; n, its delimitation by a shallow internal groove; o, later stage; p, the same as last, but invaginated; q, the enclosing of the parasite by a second outer furrow; r, a fully developed scolex with head inverted. (Original.)

(r). In each daughter cyst (d, e) five to ten, or even as many as thirty-four heads may develop, so that the entire number in one echinococcus reaches into the thousands. By the rupture of the brood capsule scoleces may extend directly into the cavity of the hydatid or, even be found floating in its contents. The echinococcus is now mature, and if eaten by a suitable host these scoleces will develop in its alimentary canal into adult tapeworms.

The form of the hydatid cyst is subject to considerable variation, the more extreme types of which have received specific names. Evaginations in the wall (a) frequently occur under mechanical influences in the environment and suggest the origin of the form known as E. racemosus (Fig. 1231), from which, however, E. multilocularis cannot be distinctly separated in all cases. The latter, known also as an alveolar coloid, represents a mass of many small hydatids 0.1 to 5 mm. in diameter which in section display numerous irregular cavities filled with a transparent gelatinous substance and embedded in a common stratum of connective tissue. Gall duct and blood-vessels may be detected in places, but the liver cells are completely atrophied. These growths were long interpreted as cold tumors until Virchow demonstrated their hydatid origin. The scoleces or hooks, often rare and single or at most a few in any bladder, are entirely wanting in forty per cent. of the specimens tested. These multilocular hydatids undergo regularly degenerative processes by which a central cavity is formed filled with a fluid containing among tissue remnants also calcareous corpuscles, secondary bladders, brood capsules, scoleces, hooks, hexamoidin and marginar crystals, concretions, etc. The size of the

Fig. 1231.—Echinococcus racemosus. Natural size. (After Leuckart.)

hooks (Fig. 1232), which varies very considerably, is due, as Leuckart has shown, to the age and stage of development of the specimen.

Annuae.—A specimen of T. echinococcus has been described with six suckers on the head. Regarding the larval form some observers hold that the varieties noted above as Aechmatocryptis, E. racemosus, and E. multilocularis are abnormal. According to others the latter form, which appears to be confined to Switzerland, represents a different species from the common type. Isolated cases have, however, been reported from other localities, one even from the United States (Stiles).

Distribution.—The adult parasite appears to be most common in Iceland, where it occurred in 28 per cent. of the dogs examined. In Australia the percentage is even higher, 40 to 50 per cent. being recorded. On the continent of Europe it occurs in from 0.4 to 7 per cent. of the dogs examined in different localities. Stiles records its presence, though very rarely, in dogs examined at Washington, D. C. I have found no other record of the presence of the adult tapeworm in this country. When present its occurrence in large numbers is natural. The hydatid is most abundant in Iceland and in India, where from one-fourth to three-fourths of all domestic animals are infected. In Germany, where records are of a most precise nature, the percentage of infection varies very greatly, being as low as 5 per cent. in a few cases and as high as 65 per cent. in one locality (for precise figures see Stiles and Hassall, p. 129). In the United States hydatids have been recorded from cattle, hog, and camel, and for localities in Maryland, the District of Columbia, Missouri, Nebraska, and Louisiana. In New Orleans 117 cases of liver echinococcus were recorded from 2,000 hogs.

In man the frequency of hydatid disease corresponds in general with that for domestic animals. In Iceland estimates of the number of inhabitants infected vary from 2 to 15 per cent.; in Australia, in 3,000 cases were reported between the years 1861 and 1882. In Europe the results of autopsies are given in the table at the top of the next page, which is taken from Ostertag.

In this country the hydatid is rare in man. Sommer has compiled statistics of one hundred recorded cases
from which the following data are taken. It is entirely unknown how many patients were infected outside the limits of this continent; certainly some of them acquired the parasite in other countries.

### Classification by Habitat

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<thead>
<tr>
<th>Location</th>
<th>Total number of autophores</th>
<th>Hydatids Present</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Cases</td>
<td>Percentage</td>
</tr>
<tr>
<td>Rostock</td>
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<tr>
<td>Breslau</td>
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<tr>
<td>Berlin</td>
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<td>Gottingen</td>
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<td>Dresden</td>
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<td>Vienna</td>
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<td>Prague</td>
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<td>Erlangen</td>
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#### BY SEX

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<td>Females</td>
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#### BY NATIVITY

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#### BY STATES

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<tr>
<td>Washington</td>
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#### Prevention

As "hydatid disease is the most fatal zoopathogenic disease which affects man, fifty per cent. of the cases dying within five years after infection," too great insistence cannot be laid upon the necessity of guarding against the disease and stamping it out. Measures should be taken to destroy all stray dogs, to prohibit the presence of dogs at abattoirs, to destroy all hydatids found in slaughtered animals, and to discourage all intimate association with dogs. Methods for the treatment of echinococcosis diseases in man have been suggested, but surgical interference alone has met with satisfactory results.

**Pathology**—the larva gives rise to the hydatid or echinococcus disease, the symptoms of which vary with the seat of the parasite. Cases are on record in which the hydatid has existed for 2, 4, 8, 15, 18, and even 30 years in man. It may be found in any organ, but is most frequently recorded from the liver or lungs. At times its presence is not suspected until revealed by post-mortem examination; and the danger depends in any case upon the precise location and the size attained by the hydatid.

In some situations hydatids exert a fatal pressure upon important vessels or nerves or destroy the tissue of essential organs. They often cause fatal results by bursting into a serous cavity or a blood-vessel, the toxic effect of the fluid having been noted already. Somer gives the following table for 1,800 cases recorded in various countries:

#### United States, Canada, and Other Countries

<table>
<thead>
<tr>
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<th>Canada</th>
<th>Other Countries</th>
<th>Total</th>
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<td>Liver</td>
<td>62</td>
<td>7</td>
<td>942</td>
<td>1,011</td>
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<tr>
<td>Large intestine</td>
<td>6</td>
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<td>Abdominal wall</td>
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<td>9</td>
</tr>
<tr>
<td>Vomited</td>
<td>2</td>
<td>2</td>
<td>3</td>
<td>7</td>
</tr>
</tbody>
</table>

**Fig. 1233.**—Anterior End of Davainea madagascariensis. x 14. (After Blanchard.)

The growth of the cestode is very rapid. At 8 cm. from the head proglottides may be seen in copula. The last hundred segments, which make up more than half of the entire length of the worm, contain only eggs about which the capsules are forming. The characteristic appearance of the ripe proglottis is given in the figure (Fig. 1234). Of the development nothing is known. Blanchard surmises that the larval host is a cosmopolitan insect (e.g., cockroach), which tallies well with known facts regarding the parasite.

Ten cases of the occurrence of this cestode in man are
Figs. 1234-1236. - Ripe Proglottis of *Diplostomum mammorial* (After Iwamoto.)(After Leuckart.)

Fig. 1235. - Entire Specimen of *Hymenolepis nana* in 15. (After Leuckart.)

Fig. 1236. - Specimen of *Hymenolepis nana* with Rostellum Retracted, X 90. (After Leuckart.)

Fig. 1237. - Anterior End of *Hymenolepis diminuta*. Magnified. (After Zschokke.)

Fig. 1238. - Reproductive Organs of *Hymenolepis diminuta*. (Letters as before.) Magnified. (After Zschokke.)

on record; they are distributed over the tropics, including both hemispheres. With one exception all individuals affected were infants or children. Although not yet recorded from any other host, it should be noted that the species may be only an adventitious parasite of man.

*Hymenolepis* Weiland 1838; *Diplostomum* Weiland. - Scobex small, rostellar retractile, armed; suckers unarmed. Genital pores on left margin; three testes in each proglottis. Ripe uteri fill entire proglottis. Eggs spherical or elongated with three widely separated membranes. Larval stage a cercocystis or staphylocystis.

*Hymenolepis nana* R. Blanchard 1891; *T. tigrina* Bilharz, *Diplostoma nana* Weiland. - Length (Fig. 1235) 10 to 15 mm. rarely 20 mm., breadth 0.5 to 0.7 mm. Special proglottides 0.55 to 0.3 mm. in diameter with retractile rostellar armed with a single circle of twenty-four to thirty hooks which are only 14 to 18 u long. Neck long, proglottides about one hundred and fifty in number, very short, the largest measuring only 0.4 to 0.9 mm, wide by 0.14 to 0.3 mm. long. External egg membrane measures 60 to 40 rarely 20 u, in diameter, the onchosphere membrane 16 to 20 u. Adult in the small intestine of man. The development of this species is still unknown. Grassi regards it as identical with *H. marina* from the rat. According to his investigations this latter form develops directly without any secondary host, so that the chance consumption of ripe proglottides or of onchospheres would ultimately produce the adult tape-worm. Other authors have emphasized a series of differences in detail which militate against the identity of the two forms. Grassi considers them to be identical, but with six persons who has swallowed ripe proglottides of *H. marina*, Grassi obtained specimens of *H. nana* only once, which in a region where the latter is abundant proves unusual. On the other hand the same investigator was unable to infect rats by feeding them ripe proglottides of *H. nana*. The evidently close relationship of these two species is preservation in favor of a similar mode of development. Discovered in 1851 by Bilharz in Egypt it has been reported occasionally from Russia, Germany, England, France, Argentina, and the United States. In Italy it appears to be comparatively abundant.

The single record of its occurrence in the United States (Sponer, 1875) is somewhat uncertain since the author mentions the possibility that the form described belonged to the following species.

*Hymenolepis nana* has been found chiefly in infants, less commonly in children, and only very rarely in adults. It occurs in considerable numbers, two hundred and fifty to one thousand and over, and gives rise to more serious disturbances than are attributable to the large cestodes. In addition to gastric disturbances, secondary reflex nervous symptoms, even epilepsy, have been observed; though of long standing they disappear with the removal of the parasites.

*Hymenolepis diminuta* R. Blanchard 1891; *T. tigrina* Weiland, *D. leucophoca* Creplin, *T. floricornuta* Weiland, *T. carinata* Parona, *T. minor* Grassi. - Length 20 to 60 cm., width 3.5 mm. (Head (Fig. 1237) small, claviform, with rudimentary unarmed rostellum. Neck short. Proglottides short and indistinct at first, increasing gradually to a maximum near the posterior end of the chain of 0.66 mm. long by 3.3 mm. wide. External egg membrane, 60 to 80 u in length, internal with polar projections; onchospheres, 36 by 25 u. Adults in small intestine of various rats and mice, and rarely also of man; larvae (cercocystis) in various insects, chiefly the meal worm (*Aegia ferri-talis*).

The structure of the species is typical of the group. It has been studied with great care by Zschokke. The arrangement of organs in the sexually mature proglottides is evident from the figure given (Fig. 1238). In the ripe proglottis the egg-filled uteri occupies the entire space within the walls of the segment save for the large flask-shaped cirrus. Sterile proglottides of smaller size and without eggs occur at times in the series. The larval form, a cercocystis, occurs in many insects, Lepidoptera, Coleoptera, and Orthoptera. Its usual host is the larva and adult of a small moth (*Aegia*). The development to the adult form has been observed in white rats and in man where some fifteen days intervene before the appearance of ripe eggs.

This species was first collected from man in Boston in 1842, and described by Weiland in 1858; who regarded it as a new species, *T. floricornuta*. In 1884 Leuckart recorded it from Philadelphia. It has also been observed as a human parasite in Italy and France, and may be met with more widely since its normal host, the rat, is a cosmopolitan.

Hencefore it has been found only in infants and children, and the introduction of the larval parasite was probably due to eating fruit or other food in which an infected insect or grub was concealed.
REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

DIPYLIDUM R. Leuckart 1863. — Rostellum retractable, armed with several annular rows of alternating hooks. Genital pores opposite, organs doubled. Uterus at first a reticulum, which later becomes changed into sacs holding one or more eggs each. Eggs with double shell.

DIPYLIDUM CANNINUM Railliet 1893; T. montiformis Pallas, T. cucumerina Bloch, T. elliptica Batsch.—Length 10 to 40 cm., greatest width 1.5 to 3 mm. Scolex elongate with retractable claviform armoured stumps attached by three or four rows of thorn-shaped hooks which decrease in size from 15 μ in the first row to 6 μ in the last; suckers elliptical, neck short. First proglottides small, becoming trapezoidal and finally characteristically of melon-seed form. Eggs spherical, 43–50 μ in diameter; onchosphere, 32 to 36 μ in diameter. Adult parasitic in the small intestine of the dog, cat, and rarely also man. Larva (cryptocystis) in the body cavity of the dog flea and dog louse.

The most striking feature of the structure of this species is the doubling of the reproductive organs, a complete set with genital pores and copulatory organs being present on each side of the proglottis (Fig. 1249). The branches of the uterus, however, become cut off as small capsules containing eight to twelve eggs each; in the ripe proglottis the mass of such capsules fills the entire middle field, and a reddish-brown substance deposited around the eggs imparts a characteristic pink color to the egg-segments. Prismatic and fenestrated specimens have been observed, and also individuals in which four sets of organs lay in a single proglottis.

The onchosphere is transformed in the body cavity of the dog flea, or even of the human flea, into a tailed larva, or cryptocystis. When the dogs, annoyed by the work of the fleas, hunt out and destroy these pests, it is easy to see how they infect themselves.

With a single exception all recorded cases of this tapeworm in man are among children who have by some chance obtained the larva of the parasite from playing with dogs. The first case on record dates from Linnaeus, and other cases have been reported from Englund, Ger-

many, France, Russia, and Scandinavia. Judging from the frequency of the parasite in dogs in this country, similar cases should not be rare here. I have found none definitely recorded.

The order Pseudophyllidea is characterized by the presence on the scolex of two poorly developed sucking grooves which may be in some cases much modified. Of the three sexual pores the uterine orifice lies always on one surface of the proglottis, whereas the two others may be on the same or opposite surface, or on the margin of the proglottis. The sexual organs are generally single, rarely doubled; no single development does not transcend the stage of maturity so that no parts degenerate. Eggs usually with cover. Among the twenty-one genera known, only two are of immediate importance here.

DIBOTHRIEOCEPHALUS Lühe.—Scolex elongated; suckers not powerfully developed; genital organs single; genital pores ventral; uterus in coils in centre of the proglottis producing a characteristic rosette figure (Fig. 1241).

DIBOTHRIEOCEPHALUS LATUS Lühe 1899; Tenia lata

FIG. 1240.—Median Portion of Sexually Mature Proglottis of Dibothriocephalus latus, Showing Female Reproductive Organs. (×25, From Railliet, after Leuckart.)

FIG. 1241.—Ventral Aspect of Sexually Mature Proglottis of Dibothriocephalus latus, Showing Female Reproductive Organs. (×25, From Railliet, after Leuckart.)
short distance behind the common opening of the cirrus and vagina. In the last proglottides the uterus is often empty of eggs and the genital glands are atrophied.

**Proglottides.**—The numbers of brownish, elliptical eggs in which may be distinguished the egg cell surrounded by masses of yolk cells. After lying in water several weeks a ciliated onchosphere (? Fig. 1290) is hatched out and swims about in the surrounding water. Sometimes this embryo throws off the ciliary covering, but ultimately dies without attaining any further development. How the onchosphere becomes transformed into a plerocercoid remains still undiscovered. Braun was inclined to believe in the necessity of another intermediate host, and Leuckart and others have endeavored in vain to infect directly with oncopheres the various fish which harbor the larval form. The bladder worm of *Dibothriocephalus latus* was first discovered by Braun in the muscles and visera of food fish in the Baltic provinces. It is an elongated form known as a plerocercoid (Fig. 1342), and measures 8–30 mm. in length. These larvae were abundant in fresh fish from Dorpat markets, and living specimens also occurred in salted, and frozen fish as well as in the roes of the pike, which salted are eaten raw as caviar. Experimentation on dogs, cats, and man established the connection of this larva with the adult *Dibothriocephalus latus*. Other authors in Switzerland, especially A. P. Leuckart (Geneva), have discovered the larva in perch, salmon, trout, grayling, and whitefish, and in some instances have determined experimentally their relation to the species of cestode under consideration, confirming fully the discoveries of Braun. In Bavaria, Switzerland, and Japan the existence of the plerocercoid in various fishes and the consumption of some part of the latter in a raw condition by the native population explains the method of human infection which has been further determined experimentally in specific cases.

Once introduced into the human alimentary canal the development of this tapeworm is very rapid, being from 5 to 9 cm. per day in the various cases. Eggs appear in the feces of man in from twenty-four to thirty days after infection.

**Anomalies.**—Slender specimens (var. tenella) have been recorded, as also some with exceptionally large proglottides. One specimen of the prismatic variety is on record (cf. *T. oviscula*) and fenestration of greater or less extent is often met with. The plerocercoid larva has been described by Maruyama (Tokyo) and others, and it is probable that the name *Dibothriocephalus* is to be retained for the species described by Leuckart, and some species resembling it have been described by Murata (Japan) later in the year 1900, which he named *D. japonicus* (var. tenella). However, it is often noted, in other cases are noted gastric and nervous disturbances, and even pernicious anemia, which disappear with the removal of the worm. These troubles have been attributed to the production of some toxic substance by the parasite. It should be noted that a self-infection is impossible.

**Dibothriocephalus cordatus** (Leuckart 1892).—Length, 80 to 115 cm. Head (Fig. 1243); 2 mm. in diameter, flattened cordiform, with deep bothridia on ventral and dorsal surfaces. Segmentation begins directly behind the head; the proglottides, which increase rapidly in width, become mature within 3 cm. The largest proglottides measure 7–8 mm. in length by 3–4 mm. in breadth and number about six hundred. Eggs, with cover, measure 75 by 50 μ. Adult parasite in seal, walrus, dog, and man in Greenland; larva unknown. The adult is a common parasite in its native land, but records of its presence outside of Greenland are based on errors. However, sporadic cases may occur in those whose food while visiting its native home.

The intermediate host is doubtless a fish.

**Dibothrium mansoni** Ariola 1900. *Ligula mansoni* Cobbold; *Dibothriocephalus liguloides* Leuckart; *B. mansoni* R. Bl.;—Adult unknown. Larva a plerocercoid; length, 12 to 20 cm. total length, 30 to 55 cm.; breadth, 28–12 mm. Flattened without proglottides, but marked by irregular folds. Anterior end enlarged, bearing the head which may be drawn in or evaginated, and on which two faint bothridia are visible. Parasitic in connective tissue of man in Japan and China.

Ten cases of the occurrence of this parasite are reported, one from China and the rest from Japan. It was first found by Manson in an autopsy when a dozen specimens were taken from below the peritoneum, and one free in the perforated cavity. Tsun and Murata have described in detail seven cases from Japan; in three the parasite was passed with urine or taken from the urethra, in three cases also it was drawn from tumors of the eye, and in one from a cavity in the subcutaneous connective tissue of the thigh.

Doubtless the larva wanders about in the body of its host, in which, as appears from the details of the last case cited, it may remain active as long as nine years. Ultimately it reaches the surface of the body or of an internal organ (bladder) or the peritoneal cavity. It eventually attains the exterior of its origin or its further development nothing is known. No trace of reproductive organs could be found in the specimens studied. In its unusual size and in the presence of longitudinal grooves on the ventral surface, this larva resembles the following species of which the adult alone is known.

**Diplagnostorhynchus Lümborg 1892; Krohbee R. Blanchard 1894.**—Genital organs doubled in each proglottis; in other respects identical with those of *Dibothriocephalus*. Genital orifices of each set ventral on either side of the median line of the body, but in the median line of either uterine field.

**Diplagnostorhynchus grandis** Lähte 1899; *Krohbee grandis* R. Blanchard.—Length, 10 meters or more; maximum breadth at anterior end 1.5 mm., in broadest region 25 mm. Proglottides very short, near posterior end only 0.45 mm. in length by 14 to 16 mm. in breadth. Scolex unknown. Genital organs double; two lateral rows of sexual openings on the ventral sur-
man in Japan; larva unknown. The first account of this remarkable species was given by Ijima and Kurimoto. It is unique not only in the extreme size manifested, but also in the double genital apparatus which occurs in some species from seals, but save for this species is unknown among human parasites of this group. The sexual organs (Fig. 1244) are characteristically bothrocephaline, but they are found in double sets right and left in each segment, and the orifices open at the bottom of two longitudinal grooves which are characteristic features in the appearance of the worm (Fig. 1245).

The authors report that the patient had suffered for five years from diziness and colic which had finally become so severe as to call for his admission to the hospital at Nagasaki. Here the parasite was removed and even on the following day all the trouble of long standing had entirely disappeared. In view of our rapidly growing intercourse with the East this should be looked for among the unwelcome additions which are sure to be made to our helminthological fauna. Quite recently Kurimoto has given an account of a second case (also from Japan) in which two specimens of the same parasite were passed. Unfortunately, both scolices were wanting here also, but other particulars the agreement with the original specimen of this species was complete. Anomalies such as fenestration, intercalated proglottides, and those of asymmetrical form were frequent. Henry B. Ward.

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The water is a light chalybeate. There are also traces of hydrogen sulphide, carbonate of magnesia, crenate of iron, and a minute trace of nitric acid, lithium, and organic matter. The proportion of soluble sulphydric acid is larger than usual. This compound is not used in medicine, but silica is contained in the human body, and may not be without therapeutical value. It is possible that the trace of sulphated hydrogen also slightly influences the action of the water. It has been recommended in all cases requiring a chalybeate water. The flow is abundant, being about twenty-five gallons per minute. Near by is a sulphur and magnesium spring, but no analysis has been made of the waters. The improvements are extensive, consisting of two hotels and cottages, sufficient to accommodate five hundred guests. Bathing facilities are ample, both hot and cold water being supplied. The climate of this region is of a salubrious character. James K. Crook.

CHAMELIRIUM. See Uniform Boot, False.

CHAMIQUEL.—Coalcoman, Michoacan, Mexico. A lukewarm mineral water classified by Dr. Zuniger as a sulphureted calcic water, and containing, according to analyses, of Coalcoman, carbonic acid, large quantities of lime and magnesia, silica, and traces of copper and iron.
Hirudinea
the range of overextension apparently represents normal flexion. In such cases the leg may be brought to the straight line, but greater flexion is resisted by the retracted tissues, and when the pressure of the hand is removed the leg is drawn back to the deformed position by the contraction of the quadriceps extensor muscle.

If recurvatum is not infrequently accompanied by varus or valgus deformity at the knee, more often by the latter, and by laxity of the ligaments. In many instances the patella is absent or rudimentary and not infrequently deformity is accompanied by malformations or defects of other parts.

Etymology.—The deformity in cases of simple recurvatum may be explained by an abnormal and fixed position in utero, and in cases seen soon after birth the mechanism is clearly shown by the habitual attitude. The thighs are sharply flexed on the body, the dorsal surfaces of the hypertrophied knees are in relation to the abdomen, while the feet may be brought into contact with the face or trunk according to the degree of deformity. The re- tarded development of the quadriceps extensor muscle explains the rudimentary patella, which is often an accompaniment of the deformity.

Treatment.—The treatment of the hypertrophied knee is very simple. It consists in massage of the atrophied and contracted musculature, combined with more or less forcible manipulation and direction of the deformity. But often the case, the leg seems to be drawn forward by spasmodic muscular action, the methodical massage should be combined with the use of a simple posterior splint.

In the more extreme cases manual force may be applied under anesthesia, and the deformity may be overcome at one or several sittings according to the resistance of the contracted parts. The leg is then fixed in a flexed position until the tendency to recurrence has been overcome. When this comes, the patient is told to walk a little; lateral bracing may be necessary to insure perfect functional use of the joint, as in many instances laxity of ligaments and muscular weakness may persist for a time.

rudimentary or absent patella.—As has been stated, a rudimentary patella is a frequent complication of genu recurvatum, or of any congenital defect or deformity of the knee or limb that involves imperfect development of the quadriceps extensor muscle. In many cases of this type it is impossible to distinguish the patella during the early months of infancy, but later a minute patella may be seen in X-rays that slowly increases to an approximately normal size.

Absence of patella under the same conditions is less frequent, although Potel collected one hundred cases from literature.

Treatment.—The treatment of rudimentary patella is included in the massage and stimulation of the atrophied or rudimentary muscle with which it is usually associated, and the support that the weak or deformed knee may require.

HIPPOCRATIC OATH.—The ancient Greek writings commonly called "The Works of Hippocrates of Cos" were judged even by the ancient Greek critics to be really by various hands. The truth of this is proved by modern scholars. These writings have probably existed in some sort a collection since the early days of the Alexander Library near the beginning of the third century B.C.; and the composition of the several writings may safely be referred to the fifth or fourth century. Which of them are truly works of the famous physician whose name they bear is quite uncertain, as no direct contemporary testimony exists. Modern critics can only sift internal evidence, and compare the views of earlier critics, ancient, perhaps, but often naive or biased. Many writings in the collection, however, are plainly as old as Hippocrates, if not older. He was born in 460 B.C.; died, probably, in 407 B.C.; and was a worthy of the great period often styled that of Pericles. There is no proof, however, that Hippocrates was ever at Athens, though he was known there; and scarcely anything is known of his life with certainty.

One of the most famous writings of the Hippocratic collection is that entitled "The Oath." It is probably at least as ancient as Hippocrates, but that he composed it can neither be affirmed nor denied. Traces of its widespread influence occur in history; and by means of it modern physicians still hold down the traditions of them calling to those about to receive a medical degree. The ancient words do not accord with the changes wrought by twenty-two centuries in men, beliefs, and manners; but no modern words can be nobler, and the ancient thoughts are vital to the modern oath. The following translation of the Greek, original into English is by the present writer:

The Oath.

I swear by Apollo the Physician, and Æsculapius, and Hygeia, and Panacea, and all the gods and all the goddesses—and I make them my judges—that this mine oath and this my written engagement I will fulfill so far as power and discernment shall be mine.

Him who taught me this art I will esteem even as I do my parents; he shall partake of my livelihood, and, if in want, shall share my goods. I will regard his issue as my brothers, and will teach them this art without fee or control.

I will give instruction by precept, by discourse, and in all other ways, to my own sons, to those of him who taught me, to disciples bound by written engagement and sworn according to medical law, and to no other person.

So far as power and discernment shall be mine, I will carry out regimen for the benefit of the sick, and will keep them from harm and wrong. To none will I give a deadly drug, even if solicited, nor offer counsel to such an end; and I will not administer to a woman the means of abortion, but will help to preserve her life and her infant.

I will give instruction by precept, by discourse, and in all other ways, to my own sons, to those of him who taught me, to disciples bound by written engagement and sworn according to medical law, and to no other person.

So far as power and discernment shall be mine, I will carry out regimen for the benefit of the sick, and will keep them from harm and wrong. To none will I give a deadly drug, even if solicited, nor offer counsel to such an end; and I will not administer to a woman the means of abortion, but will help to preserve her life and her infant.

The best Greek text (from which the foregoing translation was made) is that of E. Littre, "Œuvres complètes d'Hippocrate," etc., tome 4, Paris, 1844, pp. 628 to 629.

Many commentaries have been published upon the oath. Among these, special mention is desired by Littre's Argument, l. c., pp. 610 to 625; and by the notes of C. Durenberg, "Œuvres choisies d'Hippocrate," second edition, Paris 1855, pp. 1 to 11.

The following matters require discussion, more or less brief:

Hygeia and Panacea were daughters of Æsculapius.

The distinction between "precept" and "discourse" (παραγωγής τι καὶ ἀκροβατείας) has not been explained satisfactorily.

"Suppository" is perhaps as nearly equivalent as possible to the Greek word πυροτήσιον, which doubtless means, in the oath, a sort of medicated pledge to be withdrawn after a longer or shorter time. Many formulations for making such, for various purposes, are given in the Hippocratic collection.

The words "destructive suppository" (πυροτήσιον φίλουρον) refer to abortion. A parallel and fully developed phrase, τικί, "a wine destructive to embryos" (φίλουρος ἑρπετίνον).
Hirudinea.

REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

Hirudinea.

amiliar (dead) occurs in the Materia Medica of the later Greek physician Dioscorides, of the first century A.D. (Lib. v., cap. 77, ed. Sprengel, vol. i., p. 734). Although abortion is abjured without qualification in the oath, there were probably Greek practitioners of the time of Hippocrates who made a distinction similar to the modern one between justifiable and criminal abortion; for methods of emptying the uteri are frequently and quite simply referred to in the collection, though they are expressly aimed at by embyos styled "dead" or "alive" or "motionless" or "stricken" or "apoplectic."

But there is also good reason to believe that, in Hellas, the amiable guilt and innocence in the matter of abortion did not always coincide with that drawn nowadays. The clear recognition of the fact that the early embryo is from the instant of conception a human being, truly alive and possessing the right to live, even before the amnion is in place, is a more matured knowledge of physiology than the ancients could command. In the ideal State discussed in Plato's dialogue of the "Republic," certain embryos irregularly begotten were to be made away with before birth (Ed. 533*). On the other hand, Aristotle, born a few years before the death of the great physician, and was himself an Asclepiad, i.e., a physician's son. Aristotle, in his "Politics," expressly recommends abortion in cases of certain of the number of children, but enjoins the procuring of it "before the advent of sensation and life." The presence of these he formally makes the criterion of "the hallowed" and the reverse in this matter (Politica, vii., cap. 16, ed. Ac. Boruss., p. 1323, b 19 to 26).

The treatise "On the Nature of the Child" in the Hippocratic collection, the author, who may not have been of Cos, but possibly an adherent of the rival school of Chios, describes a certain case as one of abortion that the sixth day deliberately procured by himself. The circumstances are given in detail, and plainly stamp the case as criminal according to modern ideas; but the author relates it without a trace of guilty consciousness, adhering, one may conjecture, to the doctrine of "naturality" by Aristotle ("Hippocratos de Nat. Puerto," § 13, Ed. Littré, vii., p. 488). The following striking passage both shows us "strict constructionists" of the Hippocratic oath nearly five hundred years after the death of Hippocrates, and sets forth explicitly, as current eighteen centuries ago, a view of the morals of abortion closely akin to that of modern physicians. The Greek gynecologist, Soranus of Ephesus, was a practitioner at Rome under the emperors, not far from the time when Juvvalat was scourging its vices with his satires. We are not more than two or three hundred years A.D. Referring to abortion, Soranus writes:

There is a disagreement; for some reject destructive practices, calling to witness Hippocrates, who says, "I will give nothing whatever destructive," and deeming it the special province of Medicine to guard and preserve what Nature generates. Another party maintains the same view, but makes this distinction, viz. that the fruit of conception is not to be destroyed at will because of adultery or of care for beauty, but is to be destroyed to aver danger impending. If the uterine be small and cannot subsist the perfecting of the fruit, or have hard swellings and cracks at its mouth, or if some other condition prevail. This party says the same thing as the former, merely regarding conception and with it the agreement. (Translated by the present writer from the Greek of Soranus, Gynecol. Lib. i., cap. 10, 16. Rose, p. 229.)

The abjuration of lithotomy in the oath contains the only mention thereof made in the Hippocratic collection. The ancient practitioners of medicine freely practised operative surgery; and no certain cause can be assigned for their refusal to cut for the stone. It has been shrewdly guessed, however, that the cause lay simply in the formidable dangers of a rude and uncertain procedure.

As the Hippocratic oath still plays a part in medicine worthy of its character and history, it has been thought proper to end this article with one of the modern adaptations. At the annual commencement of Columbia University in the City of New York, the following oath is administered to the graduating class of its College of Physicians and Surgeons:

Candidates for the Degree of Doctor of Medicine:

You do solemnly swear, each man by whatever he holds most sacred:

That you will be loyal to the Profession of Medicine and just and generous to its members;

That you will lead your lives and practise your art in uprightness and honor;

That into whatsoever house you shall enter, it shall be for the good of the sick to the utmost of your power, you will give no drug, perform no operation, for a criminal purpose, even if solicited, far less unworthy solicitations;

That whatsoever you shall see or hear of the lives of men which is not fitting to be spoken, you will keep inviolably secret.

These things do you swear? Let each man bow the head in sign of approval.

And now, if you shall be true to this, your oath, may prosperity and good repute be ever yours; the opposite, if you shall prove yourselves forsworn.

Hirudinea.—Among the Annelida or segmented worms the leeches form a well-marked order. The body of the leech is elongated, usually flattened dorso-ventrally, and provided with a prominent terminal or subanal sucker, while many forms possess also an anterior or oral sucker. The bristles all but universally present in annelids are here wanting save in a single genus, and the metamericism of the body presents a poorly marked external aspect although actually highly developed. The rings which appear in external view are mere surface markings, and are variably related to the true somites. Of the latter there are always thirty-four (thirty-five), of which those in the central portion of the body possess the typical number of annuli, while the first few and last few manifest ordinarily a reduction from that number. Prominent papillae may usually be observed on the dorsal surface in the form of six or eight longitudinal rows; these are metameric in position, and known as sensillae, and the eyes which vary in number in different forms are anterior units in certain of the rows.

The annules bearing the sensillae is now generally regarded as the central one of the typical three- or five-ringed somites, and is the only one present in case of those somites manifesting the extreme of reduction. The leeches are hermaphroditic and the two sexual pores lie in the midventral line, the male in front of the female orifice.

Fig. 2586.—Hirudo medicinalis, or European Leech. a, Ventral aspect of anterior end, showing an open mouth at the bottom of which the jaws, K, are visible; b, one of the jaws isolated, showing marginal denticles and muscles. (After Calvus.)
The family of the Gnathobdellidae, or Round-jawed Leeches, is characterized by three saw-toothed jaws in a simple pharynx (Fig. 2656); the typical somite has five annuli. Among the freshwater leeches (Hirudinea), which have an eyeless ring between the third and fourth pair of eyes, only the monostichodont forms (i.e., those with a single row of teeth in each jaw) are important, and of these only two genera need be noticed here.

Hirudo medicinalis L. — *Sanguinaria medicinalis* Saynivy 1820. *S. officinalis* Saynivy 1820. *H. officinalis* Derlemans 1835. Length 100 to 200 mm.; breadth 10 to 30 mm. Jaws large, each with 50 to 90 teeth. Color variable, darker above than below, dirty yellow-brown in tows with tendency to gray or green; at the margin a bright yellow or brown band with black margins; on the back three or more less prominent longitudinal bands spotted with black (Fig. 1057).

*This species is native in Europe, northern Africa and southwestern Asia, but is present in many regions and obtained by artificial culture or through importation only. Among the very numerous color varieties, as many as sixty-four being recorded by Diesing, two have been recognized as sub-species or varieties:*

The Gray Leeche, var. *multicinctus* str., back greenish-gray with three russet-red lines on each side, of which the middle one, and often the inner also, shows a black spot on each of the segments.

The Green Leeche, var. *officinalis*, back darker green, often with black blots on the body, prominent, though red specimens also occur. Ventral surface almost entirely unspotted. A series of intermediate forms makes a distinction even between these two varieties difficult in many cases.

The leech sucks from four times its volume of blood for the young to three times in an adult, or from 6 to 15 gm. If, however, the sucking leech be cut in two by the shears close behind the pharynx, the blood streams out in pronounced pulsation and, if the action is not interfered with, a stronger or rather longer-continued blood extraction is caused. During the ordinary operation of sucking a leech gives off a large quantity of clear fluid which exudes from the skin in drops. It is not blood serum, as often supposed, but the secretion of the nephridial canals. While this exudation ceases at the end of ten days, the assimilation of the stomach contents of the leech demands from twelve to eighteen months. At the end of two months, however, the animal manifests willingness to bite, but the appetite is not yet restored. On the other hand, the leech can fast for two years or more and may be kept indefinitely without food in suitable leech jars. A fast of from six to eight months is necessary before re-employment; but the latter is not advisable. Before the third year of their growth leeches are not used for medicinal purposes, and from eighteen to twenty years has been put as the probable length of life. For the method of using leeches, see Blood-letting.

At one time the enormous demand for leeches reached, for example, 7,000,000 per year in London alone, but in recent years their use for therapeutic purposes has greatly diminished, no doubt largely as the result of occasional fatal cases and in spite of certain evident advantages to local affections. Fatal bleeding has been known where the bite opened a large vessel (cervicaria or jugularis), or in internal organs where the leech, by careless application at the nasal fossae, vagina, or rectum, has attracted or been drawn too deeply to the proper organ. In order to guard against this leeches should be fastened in such cases by a thread passed through the middle of the posterior sucker. Several authors have investigated the reputed transmission of disease, particularly bacterial, by leeches, but uniformly only poorly known. So far as bacteria are concerned, the species studied were rapidly digested in the stomach of the leech, and the entrance into the wound of such as may be upon the lips at the start appears difficult under the circumstances of the bite.

Where native, these, like other large leeches, attack men and animals invading swamps and pools, and in recorded instances with fatal results to children or young animals.

Hirudo trivicia Johnson 1816, often confused with the medicinal leech, is distinguishable by its smaller size, 80 to 100 mm. in length by 12 to 18 mm. in breadth, and especially by the scantier number of teeth, about seventy, in each jaw; it is native in northern Africa and Spain, perhaps also Italy and Sicily, and is exported in large numbers to France, England, and America. In power to extract blood it is much inferior to *H. medicinalis.*

Hirudo nippowico Whitman 1886, also smaller in size than *H. medicinalis,* is common about Tokyo, Japan, and in other parts of the island. Its habits and use closely resemble to those of the continental species. Other species of similar habit are reported from different regions of the Orient; they are, however, only poorly known.

The genus *Lumatula* may be distinguished from *Hirudo* by the papillae on the jaws and by the ventral furrow traversing the entire length of the anterior lip of the oral sucker. One species, *Lumatula nitidiceros* Say., demands brief notice. It is abundant in the central and southern regions, and in some places is so abundant as to become a veritable pest. Especially the young, described by Moquin-Tandon as *Sanguinella aggregata,* are often swallowed accidentally in drinking and may remain for a long time in the stomach, or may be driven down even the esophagus. The species plays accordingly an important rôle in diseases of man and domestic animals in northern Africa during the hot season. European soldiers in garrison, and even natives, in spite of precautions, suffer from the leech, which evokes by its presence both local and general symptoms of serious character if assistance is not speedily afforded. With the removal of the worms rapid and complete healing of the wounds and disappearance of secondary symptoms occur almost immediately and without exception. The removal may be accomplished by instruments from those organs where the leech can be seen; in deeper locations copious application of salt water is said to be efficacious. This leech can pierce only the mucous membranes of higher animals, and its inability to penetrate the external skin, even of children, has often been demonstrated. Other species of this genus have a more powerful bite, and are used especially in the East for medicinal purposes, even though they take up less than half as much blood as *Hirudo medicinalis* in this country. One of the large native leeches is employed in some places for blood-letting; it may be recognized by the following description:

*Macrobdella* Verrill 1872. Cephalic lobe smaller than in *Hirudo,* Annuli 190; at least four in somite XXIII.
Neither buccal nor post-buccal annulii united on the ventral side. Both genital orifices in somite XI, and behind them a group of prominent copulatory glands.

_Hemadipsa deora_ - _Hirudo deora_ Say 1834, _H. deora_ Leidy 1868. Jaws with about sixty-five teeth, copulatory glands opening by four pores in a quadrangular flexure, annulii of XIX and the first two of XIV. The first annulii of XXVI is divided marginally and sometimes also dorsally into two annulii.

This species is widely diffused in fresh waters of the United States, having been reported from Maine to Minnesota, from Pennsylvania to Kansas. It is frequently used instead of imported leeches by physicians and is said to be equally efficacious, although its capacity is somewhat smaller, only about 5 gm. It is so powerful, however, that serious results have followed inadvertent upon the legs of children wading in its haunts.

Among the land leeches which form a special section, _Reptantia_, of this family, and are distinguished by the absence of an eyeless ring between the third and fourth pairs of joints, the _Hirudinidae_ Tennent. Body almost round, sucker separated only by a slight constriction. Near the sucker auricula with the pores of the last pairs of nephridia. Typical metamere with five annulii.

_Hemadipsa deora_ - _Hirudo deora_ say. - _H. japonicus_ Whitman. Length 20 mm., or in extended form 60 mm., diameter of body behind 6 mm., in front 2 mm.; sucker 5 to 7 mm. in diameter. Annulii ninety-seven; male genital pore between annuli 30 and 31, female between 33 and 34. In cony, a parasite to natives and Europeans alike. The leeches appear in immense swarms, particularly in moist regions and during the rainy season, and at all levels from the coast up to 4,000 feet, although they occur even as high as 15,000 feet in the Himalayas. During the dry season, they are found in the earth; at other times they live in moss among stones and on shrubs and trees. The approach of large animals brings them out in myriads; they move with surprising activity, and springing on the unfortunate passer-by they suck often for hours before the unfortunate observer is conscious of their presence. They can inflict large losses on European troops, attacking the soldiers even when asleep. Accounts of travel in Ceylon abound in narratives of the ferocity of these pests, and recent writers from the Philippines comment on their activity in that country in equally forcible terms. It is probably this species, and very likely the variety _japonicus_, which is reported by Blanchard as abundant in the Philippines, to which the trouble is due, although other species of _Hemadipsa_ manifest, no doubt, similar habits of life.

The bite is not poisonous, as often maintained, but the large number of wounds and careless treatment afford ample opportunity for secondary infection of a serious character. Among the natives of Ceylon one may see many deformities induced by these leeches, which are accordingly feared more than serpents and carnivores.

An allied form, _Phlogobdella Meyeri_ R. Bl., is also recorded from Laos and China.

The family of the Rhynchobdellidae, or proboscis leeches, is characterized by a protrusible pharynx, while the typical metamere consists of three annulii and jaws are lacking. Few of these forms are able to penetrate the human skin, but among those of sufficient power are especially American forms, which appear as occasional parasites of man and in some regions are used for therapeutic purposes. The two species of importance are both members of the following genus, which is restricted to the warm regions of the American continent.

_Lisotoma Wagler_ 1831 — _Hirudinaria_ de Fil. 1849. Body broad and flattened; back covered with many prominent papillae; the first and third ring of each somite, from VI. to XXII. inclusive, split on the ventral surface so that the central space occupied by five pseudo-annulii corresponds to that occupied by the three adjoining dorsal annulii. Male genital pore between annuli 26 and 27, female between 28 and 29. Two pairs of eyes so closely set that they appear as a single pair.

_Lisotoma guianensis_ Wagler 1831 — _Hirudinaria Chilensis_ de Fil. 1849. Length of alcoholic specimen 190 mm., breadth 100 mm., corresponding to a probable length while living of 350 to 400 mm. Annuli seventy, together with three preocular; the first seven annulii form the oral sucker.

This giant form inhabits the basin of the Amazon and the swampy regions of Guiana. Blanchard reports that it attacks horses and cattle, and a few individuals are sufficient to kill even a full-grown animal.

_Lisotoma guianensis_ Wagler 1831 — _Hirudinaria efficiensis_ de Fil. 1849, _H. mexicana_ de Fil. 1849, _Glossiphonia granulosa_ Jimenez 1865. Length 80 mm., breadth 22 mm. Annuli seventy, with two preocular; the first six annuli form the oral sucker (Fig. 2928).

The range of this species extends from Mexico to Paraguay through Central and South America. In Mexico it is universally used as the medicinal leech. In some instances, however, its bite appears to be accompanied by serious results. There are noted almost immediately a feeling of general lassitude and an unpleasant itching and twitching, succeeded soon by general urticaria, and in a short time apoplectic symptoms are manifested; but these occur in which the cerebral congestion or the urticaria are wanting. It may be true that the saving of the salivary secretion poured into the bite by the leech, and yet it seems also clear that some predisposition on the part of the individual may also play a rôle. It is suggested that the symptoms of poisoning are manifested only in persons exhibiting hyperesthesia, and attributes the rare cases of serious illness following the application of _Hirudin medica_ in Europe to the same sensitive constitution. On the contrary, in those Kant's experiments, the effects produced by the bite of Argas, as reported by Brandes and noted in the article _Arachnida_, Vol. I., p. 437.

In spite of these accidents this is actually the only species used for medicinal purposes in Mexico, sufficient evidence of its generally satisfactory character. In some provinces (Guadalajara) the leech is regularly cut in two after it has taken hold in order to measure definitely the quantity of blood extracted.

_Henry B. Ward._
**Principal Articles Used.**


Leuckart, R.; Die Bremsien des Menenchen, etc., Zweite Aufl., Lief. 5, 1894; Lief. 6 (Nach dem Tode des Verf. bearb. v. Dr. G. Brandes), 1901.


Also shorter papers by the same authors, Leidy, J. P. Moore, and others.

**HISTOLOGICAL TECHNIQUE.—Methods of Studying Living and Fresh Tissue.—** For observations on living tissue, we now make use of the cold-blooded ani-

mals almost exclusively; and, on account of the convenience, use the tails of amphibian larvae, and small fishes and frogs. For holding the small ones, while under observation, the larva holder of Schultzer (Fig. 2659) will be found very convenient. The head of the animal is placed under the edge, $a$, the tail is spread out on the bevelled plate, $b$, and covered with a cover-glass. The cell holds sufficient water to cover the animal. To keep the animal quiet, we wrap it loosely in a piece of cloth, leaving the gills free, or add a few drops of ether to the water. If the observations are to be continued for any length of time, provision must be made for the renewal of the water. This can be accomplished by any of the usual methods of irrigation.

For observations on the frog, it is necessary to paralyze the animal with curare. A slight nick is made in the skin over the posterior part of the head, and two or three drops of a one-twentieth-per-cent. solution of curare* is injected into the dorsal lymph sac by means of a long, slender pipette introduced through the above nick. The exact amount of curare to be used will depend upon its quality and the size of the animal, and can be determined only by experiment. In the course of a few hours the animal will become completely paralyzed, while the vegetative functions continue, the necessary amount of oxygen being supplied by cutaneous respiration.

We utilize for these observations:

1. The Web.—The advantage of this part of the animal is that we do not inflict any injury, consequently we are not likely to meet with any disturbances of the vital processes; but, on account of it not being very transparent, it is inferior to other parts. A frog poor in pigment should be selected, and after being wrapped in a moist cloth it is laid on an oblong sheet of cork, in one end of which a hole at least 15 mm. in diameter, is made; at the edges of this hole four or five pins are stuck, to which bits of soft string attached to the toes are tied, spreading the web out over the hole. The cork is now placed on the stage of the microscope, and the web is moistened at intervals to prevent its drying.

2. The Tongue.—For observations on this and other organs of the animal, Professor Thoma has invented a series of frog plates, which are shown in Fig. 2600. The one in the centre of the figure is for the tongue, that on the left for the mesentery; that on the right for the hind and bladder. These plates consist of a bed plate, $a$, of brass, covered by a thin sheet of hard rubber. At $B$ is an opening, which varies in the different plates, covered with a thick glass plate on which the organ to be examined is placed. At some distance from this glass plate runs the brass rim, $c, c, 7$ mm. high, which by a proper inclination conveys the irrigating fluid, as it flows off the organ, to the tubes, $d, d, d$, to which are attached hard rubber tubes leading to a vessel for receiving the waste fluid. The supports, $t$, are for holding the irrigating cannula, $g$. They are pivoted to the plate, and move on a perpen-


*8. H. Gage recommends the following solution: Curare, 0.2 gm.; ninety-five-per-cent. alcohol, 20 c.c.; water, 20 c.c. Grind up the curare in a mortar with the water and alcohol. Do not filter.
as to cause the fluid to flow into the bladder, distending it. The animal is now placed on the frog plate, and by gentle manipulation with the handle of a scalpel the distended organ is brought upon the glass plate and fur-

ther distended if necessary; the glass rod is now replaced in the rubber tube, and the latter fixed in the support (4, Fig. 2660). The animal is covered with a bit of moistened filter paper, and the frog plate is placed on the microscope.

5. The Lung.—The cannula (A, Fig. 2661) is introduced through the epiglottis, and held in place by a thread passed through the nose and tied around the constriction of the cannula. An incision, carried well into the axilla, is made through the skin on the side of the animal, and when all hemorrhage has ceased the thoracic cavity is opened. The operator should now remove the bit of glass rod from the end of the rubber tube attached to the cannula, and gently blow into the same, when the distended lung will be forced through the incision. The animal is placed on the frog plate, and the distended lung brought upon the plate B. In Fig. 2662 is shown the arrangement of the frog plate on the microscope, and the irrigating bottle. The stage of the microscope is to be inclined so as to cause the irrigating fluid to flow away. The bottle attached to the ring stand, filled with a three-fourths-per-
cent. salt solution, is closed tightly with a rubber cork, through which pass two glass tubes. To one is attached a rubber tube, which is connected with the glass cannula (g, Fig. 2660) and conveys the irrigating fluid. The other is for regulating the pressure, which can be varied by raising or lowering the tube. The flow from the end of the irrigating cannula should be by drops, at short intervals, and is regulated by the pressure in the bottle, the size of the opening in the point of the cannula, and, if necessary, by a spring clip placed on the rubber supply-tube.

Fresh tissues are to be examined in the fluid that bathes them during life, or in a fluid that will change them but little if at all. Such fluids are known as indifferent fluids, and resemble in composition the natural fluids of the body. They are as follows:

Aqueous Humor of the Eye.—Obtained by puncturing the cornea of a recently killed animal, and allowing the aqueous humor to escape.

Blood Serum.—The blood of a recently killed animal is poured into a tall glass cylinder and allowed to conglutate. After coagulation has taken place, the upper margin of the clot is separated from the sides of the vessel, to permit it to sink; the vessel is allowed to stand for twenty-four hours, and the clear serum is then drawn off with a siphon, care being taken not to disturb the clot.

Iodized Serum.—Prepared by adding to every 1,000 c.c. of blood serum, obtained as above, 10 c.c. of tincture of iodine. This fluid alters the tissues slightly and stains them yellow. Instead of blood serum, amniotic or pericardial fluid may be used, but it must be absolutely fresh.

Artificial Serum.—This is to be used only when the natural serous fluids cannot be obtained. It is prepared by dissolving 2 gm. of sodium chloride and 38 gm. of egg albumen in 250 c.c. of distilled water, and adding 2.3 c.c. of tincture of iodine; the solution is then filtered.

Salt Solution (three-fourths per cent.).—Made by dis-

solving 7.5 gm. of perfectly dry, chemically pure sodium chloride in 1,000 c.c. of distilled water. This solution alters fresh tissues but slightly.

Fresh, thin membranes can be examined in one of the above solutions without any previous preparation. Bits of organs, fibres, etc., are to be teased on a slide, in a drop of one of the indifferent solutions, or sections can be made by the freezing microtome.

In observations on fresh tissue it is necessary to prevent evaporation, and in most cases pressure. The first can be prevented by painting a ring around the cover with oil or vaseline; the latter by placing a hair between the cover and slide; or we may use the moist chamber.

In Fig. 2663 is shown a moist chamber. In the centre of a thick glass slide is cut a cavity, around the circumference of which is a groove (pp). The latter is filled with water; the specimen is placed on the cover-glass (o), or in the middle of the cavity.

Methods of Applying Reagents.—Application of Fluids, Irrigation.—A drop of the reagent is placed on the slide in contact with the edge of the cover-glass, and on the opposite side of the cover a bit of filter paper. The latter sucks out the fluid, which is replaced by the reagent flowing in on the other side. This process of ir-
Mosquitoes.
REFERENCE HANDBOOK OF THE MEDICAL SCIENCES

MORPHOLOGY OF MORVAN'S DISEASE.

Phenomena.—In cases of moderate extent and severity the prognosis is usually fairly favorable. In the majority of cases, after a duration of some months, or it may be two or three years, the skin gradually resumes its normal aspect. When, however, marked atrophy has taken place with adhesion to the deeper structures, forming scar-like patches, the prognosis is extremely unfavorable.

Treatment.—Treatment is rather unsatisfactory. Internally such remedies as cod-liver oil, arsenic, quinine, and iron may be administered with the view of improving the patient's general health. Thyroid extract has been given with asserted good results in a small number of cases. Locally, friction with bland oils and fats are useful, and also saline and glycerine currents applied, as Crocker suggests, in the neighborhood of, rather than directly to, the patches, to avoid any possible irritant effect. Brocq recommends electrophoresis, employed as in the removal of hairs. The needle should be inserted in every portion of the patch, the current used varying from 8 to 15 milliamperes, and the needle should be allowed to remain fifteen seconds at each puncture. Between the sittings mercurial plaster is to be applied. Hebra has obtained good results from intramuscular injections of a fifteen per cent. alcoholic solution of Pravaz syringeful of the solution being injected every second day.

MORRISON SPRINGS.—Jefferson County, Colorado.

Post-Office.—Morrison. Hotel recently built.

Access.—From Denver via Denver, Gunnison, and Leadville Railroad. Morrison Springs are located fourteen miles south-west from Denver, in the basin of Bear Creek and just within the Rocky Mountain foothills at an altitude of six thousand feet above the sea level. No complete quantitative analysis of the waters seems to have been made, but Dr. W. C. McNeal, of Morrison, furnishes us the following report of a partial qualitative examination:

Subhured hydrogen, 200 mlls. Iron, 1.5 grains. Calcium bicarbonate, 100 mlls. Magnesium, 20 mlls. Sulphuric acid (Doubtless in Arsenic acid) combination, 30 mlls. Temperature of water, 60°.

This incomplete analysis would indicate that the waters possess tonic, laxative, and alterative properties. They are recommended in renal, digestive, skin, and rheumatic affections, and in chronic syphilis.

James R. Crook.

MORVAN'S DISEASE—ALGIC PANARITIUM.—This curious and extraordinarily rare disease was first described by Morvan, of Brittany, in 1883. In applying the name algic panaritium, or "painless whitlows," Morvan was obviously more influenced by the salient clinical feature of the disease than by any consideration for its underlying pathology. Viewed in the light of the more critical tendencies of recent years, the desirability of retaining it as a clinical entity, to the burden of an already overcrowded nosological nomenclature, seems more than doubtful.

The opportunities for investigating the disease, even in the services of large hospitals, are so meagre that little or no satisfactory advance has been made in our exact understanding of its genesis and mode of sub-structure. It appears to consist of a syringomyelic condition—or of the associated glomatosis—plus a peripheral neuritis.

In the few cases in which a microscopic examination of the cord has been made, the connective-tissue overgrowth appeared in the posterior part of the gray matter and in the posterior columns.

It is practically certain that syringomyelia takes its origin in a developmental defect. As the primary morbid condition of the disease under consideration is analogous to that of syringomyelia in all essential details, it seems to the writer much more reasonable to regard the extra feature of Morvan's disease, the peripheral neuritis, of identical origin. This point of view makes the two morbid processes practically alike in all respects except topography, and the doubt arises as to whether this single feature of dissimilarity is sufficient to establish Morvan's disease on the plane of a clinical entity. Repeated observations of the apparent fortuitousness of the morbid distribution in cases of other defenders of the disease should tend, by analogy, to reduce the present distinguishing features of syringomyelia and what we now term Morvan's disease to the vanishing point, and such a result is desirable for obvious reasons.

As the clinical features of the two diseases now stand, there is nothing upon which we may rely absolutely for differentiation between them. Both are apt to give the first clinical manifestations of their presence in the first half of adult life, and both are nearly general in their features, trauma, or to arise in consequence of abuse of function. How important local trauma may be in the production of Morvan's disease it is difficult to say, owing to the natural rarity of the affection. It probably has about as much etiologic value, however, as that other frequently alleged causative agent in nervous diseases—exposure to cold and wet.

In Morvan's disease the symptoms begin as a rule in the upper extremities. Of these the most striking are the whitlows, which usually begin in the form of painless, oozing lesions. They are accompanied by cyanosis of the skin near them, and the nails shaved and split. Although the occurrence of the whitlows is the striking feature of the disease, it is not the most important or serious. As has been said, they occur as a rule subsequently to the abolition of all forms of sensation, but these disappear in the form of muscular weakness and wasting in the hands and forearms. Although the trophic mischief is practically limited to the hands, and the muscular wasting does not go above the forearms, the sensory loss may involve the entire arms, parts of the trunk, and even the face. Sufficient vasomotor derangement to cause lividity and pallor of the skin often precedes and accompanies the nutritional disturbance. An affection of the shoulder-joint has been noted. When the ulcerations of the fingers involve the terminal phalanges, the latter may be entirely destroyed. The electrical irritability of the nerves involved in the affected parts pursues variations, as the disease progresses, similar to those observed in the progressive atrophies of spinal origin, a gradually increasing quantitative loss, followed by a qualitative formula. The feet are rarely the seat of the painless ulceration; although the legs may be weak and the knees exaggerated, owing probably to the partial implication of the nutritional arteries of the lateral columns in the overgrowth of tissue. The course of the disease is extremely slow, extending over many years. In certain cases it has appeared to be arrested.

In the matter of differential diagnosis there are no particular difficulties except in regard to syringomyelia. Here, in the opinion of many, there is an absolute distinction. For certain authorities the retention of tactile sensibility and the absence of the whitlows are sufficient to rule out Morvan's disease in a doubtful case. In Raynaud's disease the vasomotor disturbance is paramount and the loss of sensibility, when it exists, is not unlike in kind or degree. In scleroderma there is no sensory loss and no tendency to destructive ulceration of the finger ends. In anesthetic lesions there are ulcers whatever, while there is a tendency to pigmentary deposit in the skin areas involved.

Owing to the nature of the morbidity, the question of treatment is easily settled. No drugs are specifically indicated. Even symptomatic treatment is of little importance because of the practically painless course which the disease pursues. Quinine, arsenic, mercurial compounds are among the drugs used, but it is more than doubtful if they have exerted other than a general effect.

Joseph William Courtenay.
MOSQUITOES IN RELATION TO HUMAN PATHOLOGY.—The special importance of the mosquito as an agent in the transmission of disease has been thoroughly demonstrated by recent discoveries, a brief synopsis of which may be given as an introduction to the subject.

In 1871, Manson, by establishing the connection of mosquitoes with elephantiasis, gave the first demonstration of their culpability in spreading disease. It was the same year (1880) that Laveran discovered the intraglobular parasites now universally acknowledged as the cause of malaria. The transference of these hematozoa from one host to another by means of mosquitoes was conjectured as early as 1883 by King and in the following year by Koch and Laveran; but was first actually demonstrated by Ross, in a series of experiments between 1895 and 1899; these facts have been abundantly confirmed by many subsequent investigators. In 1897 MacCallum first observed the sexual phase in the allied avian hematozoa, and the further elucidation of the life history of the parasite was brought about by contributions of Ross, Bastianelli, Bignani, Grassi, and others, while unimpeachable evidence of the agency of the mosquito in carrying the disease was furnished by the positive infection experiments of Manson, who imported from Rome tertian infected Anopheles, which evoked the disease in those whom they were permitted to bite in London.

The connection of the mosquito with yellow fever, conjectured by Finlay of Havana as early as 1881, waited until 1900 for its experimental demonstration in the investigations of the Yellow Fever Commission, consisting of Drs. Reed, Carroll, Lazear, and Agrawal, in the course of which two members of the Commission acquired the disease and one, Dr. Lazear, succumbed to it.

Kinds of Mosquitoes.—It is necessary now to consider the various types of mosquitoes before taking up more specifically their relations to disease. In all about three hundred species of mosquitoes have been described, of which only thirty-six species have been recorded in North America. Of these five belong to the genus Anopheles, three to Stegomyia, and no less than eighteen to Culic. It would be impossible within the limits of an article even to outline the complete classification of the group, but some of the most important facts may be stated briefly. The order and family have been sufficiently characterized by Professor Osborn (see issues). It is curious that in 1880, when the group was first described by Theobald, it was considered that subdivision in the form and arrangement of the scales on the body and wings. His classification with some additions suggested by Giles is followed here. The sub-families are distinguished as follows:

Section A. Proboscis formed for piercing.

I. Brilliantly colored insects with a very long, curved proboscis,

(a) Palpi, about as long as the proboscis in both sexes

(Megorhina); or long in male, shorter in female (Tuzonichites).

Megorhina.

II. Dull-tinted insects with straight proboscis.

(p) Palpi about as long as the proboscis in both sexes: those of the male chibbed at the end, those of the female longer. Anophelina.

(c) Palpi about the length of the proboscis in the male but much shorter in the female, being here usually very short.

(d) Palpi very short in both sexes.

Section B. Mosquitoes not habituated for piercing. None of these being no true proboscis. Palpi small.

For the determination of the genera the form and arrangement of the scales, which are all important, are shown diagrammatically in the figure (Fig. 3363). So far as the species are concerned, it is impracticable to make more than a preliminary determination without referring to a monograph, and there will be mentioned only a few of the more important forms, in those genera which are now known to worth the transmission of disease. A few limits to the prolongation and mosquitoes will doubtless be useful to the practitoner. The adult mosquitoes are very delicate, so that the parts are easily broken and the arrangement of the scales easily obscured by rough handling. The female may be readily caught on the hand or arm when biting, or even on the wall of a room, by inverting an ordinary vial over it; once trapped a whiff of smoke will kill it immediately and leave the specimen in good condition for examination or transportation on cotton in a pill box. A second killing may be made by confining a small piece of cyanide of potassium at the bottom of a shell vial by a disc of blotting paper cut to fit the vial. After it has been inverted over the mosquito, the cork may be tilted into the mouth of the vial and the insect may be stored almost instantly and washed with thin card or cork, but should not be enclosed in balsam as this destroys color and renders identification difficult. Most of the characters can be determined with a tripod; all with the low power of a compound microscope.

For collecting larvae, which are often difficult to distinguish against the dark background in a pool, a white cup is useful; or a common strainer with the vegetation at the margin of a pond or stream and the material obtained may be examined more carefully in a cup of water or on a white plate. Larvae may be bred in jars, which should be covered with mosquito netting to prevent the escape of the adults when they emerge, while the latter may be kept in frames of netting, but should be provided with a little water and pieces of banana or dates on which they feed. If desired larvae may also be preserved in diluted formalin or in alcohol. Further data may be found in any of the manuals cited.

Anopheles Melign (1818).

Head with both flat and narrow curved scales, but mainly covered with large upright forked scales, palpi long in both sexes, usually about the length of the proboscis, four-jointed in the female, three-jointed in the male, in which the last two joints are short and thick; constrictions at the base make the palp possess apparently one or two extra joints in each sex. Antenna, fourteen-jointed, diliform, pilose in the female, fifteen-jointed and plumose in the male. Thorax sometimes nude on the dorsum, usually with narrow curved or small spine-shaped flat scales. Abdomen generally pilose, but sometimes with a few scales

Fig. 3363.—Graphical Key to Scale Arrangement of Leading Genera. (After Giles.)
and rarely with many. Wings covered with small scales of normal form or inflated, with the first submarginal cell longer and narrower than the second posterior cell; both the second and third long veins run past the cross veins into the basal cells, a very marked characteristic.

The etiological importance of this genus has been thoroughly demonstrated in its transmission of malaria, and it has also been shown to be instrumental in transmitting febris. As a genus it is widely distributed, with the exception of the higher latitudes. Nuttall has shown that in England this distribution compares exactly with the old limits of ague, but the genus also occurs in districts where no ague is known to have existed. It does not follow that because *Anopheles* are found, malaria is present; but wherever the latter occurs, the presence of *Anopheles* in considerable numbers has been demonstrated. *Anopheles* is moreover accustomed to fly and to bite only after sunset, so that by keeping within well-screened houses after that hour malaria is avoided even in the worst infected localities. The bite of this genus is believed to be less irritating than that of other mosquitoes and from its habits of lurking near the ground it is less likely to be discovered. Its bite is said to be less distinct than that of *Culex* and of a lower pitch. The adults hibernate in woods, and the larvae may be found both in fresh and in salt water, even after frost has occurred.

*Anopheles maculipennis* Say. Wings with the costa black, interrupted by a single large ferruginous spot a little outside the transverse veins, with also a smaller apical spot and some yellow spots near the tips of the long veins. Legs and tarsi nearly uniformly black. Thorax and abdomen deep brown, male except for some yellowish-brown hairs; wings much longer than abdomen; head black with a scanty whitish frontal tuft, palpi and proboscis dark yellowish-brown unbanded, but rather lighter at the tips, length 5 to 7 mm.

This species is very widely distributed over our continent and is said to be called the "winter mosquito," having been taken when the temperature was only 6° F.

*Anopheles maculipennis* Meigen (1818) (Fig. 3364). Wings with four tufted spots on the wing field, the costa being uniformly dark except at the apex, where its color fades to a fairly distinct spot; tarsi unbanded but with an apical yellow spot at the first joints. Thorax with four broad ferruginous stripes formed of golden hairs with the darker ground color left bare between and a tuft of large golden scales on the anterior border. Abdominal segments brown with yellowish-basal markings. Anterior femora not thickened at the base. In the female the head with two patches of creamy scales divided by a central line, otherwise with black scales; a small tuft of white hairs in front and the borders of the eyes white. Male with antennae banded, proboscis black, palpi dark brown. Length of male 4 to 7.5 mm., of the female 8 to 10 mm.

To illustrate the great variation of this species in size, Giles has drawn the wing of an Italian specimen over the wing outline of a Californian specimen from the British Museum in a figure which is here reproduced (Fig. 3353). The sub-family of the Culicinae is the largest among the mosquitoes, and its type genus *Culex* includes more than one hundred and fifty species. In addition to the characteristics mentioned in the synopsis above it may be noted that the anterior fork cell is at least as long as the hind one. Of the dozen genera only two are noted.

*Segorumia* Theobald 1901. Palpi short, four-jointed in the female; long, five-jointed in the male. Head clothed completely with an armour of broad, flat scales; mesothorax covered with either narrow curved or spindle-shaped scales. Scutellum always with broad flat scales on the middle lobe and usually also on the lateral lobes; abdomen completely covered with rows of small, banded or unbanded, but always with white lateral spots. The female palpi are small, never more than one-third the length of the proboscis; those of the male are as long as, or longer than, the proboscis. Wings of similar venation to those of *Culex*, but the fork cells are short. With hardly an exception they are colored jet black contrasted with pure white in bands and stripes on the legs and thorax, which is often elaborately adorned; in all black predominates, and they have a characteristic smooth satiny-like appearance.

As these mosquitoes are rarely found north of 40° North latitude, they are characteristically tropical and subtropical forms. They are said to be good sailors and as a result *S. fasciata* belts the world with its colonies, being the most widely distributed of all mosquitoes.
The description of this cosmopolitan species is as follows:

_Segonzia fasciata_ (Fabr.). Wings (Fig. 3366) densely clothed with very long black scales of three lengths. Last hind tarsal joints and all but the apex of the next snowy; all the other joints of the hind, the upper three of the mid, and the upper two of the fore legs of the otherwise black tarsi basally white banded. Thorax from a velvety black with reddish reflections to a golden brown. In some specimens, labellum marked with rather broad silvery lines arranged in the form of a lyre (Fig. 3367). First abdominal segment creamy white, the others black with narrow basal bands and brilliant lateral tufts of snowy white. Proboscis mostly black. Head black with narrow white orbits and two faint patches of white on the occiput divided by delicate median and lateral black lines. Of moderate size, often very small, some even with wing length not exceeding 5 mm. In some places a pure white variety is found.

The extreme variation in size and color markings has led to the frequent redescription of this form as a distinct species. Giles says that specimens hatched from the same egg lot are so widely varying as to render varietal limits decidedly uncertain. In the United States it is common throughout all the Southern States, having been found about as far north as Norfolk, Virginia, while its previous or occasional range as far as Philadelphia, New York, and New England is clearly indicated by the epidemics of yellow fever at those places about the beginning of the last century. It is said to be troublesome in the early afternoon and again at night, in contradistinction to the majority of mosquitoes, which are twilight flyers. It certainly is a hardy species, and individuals infected with yellow fever have been kept alive seventy-one days, thus showing how contagion of yellow fever may cling to a building which has been vacated more than two months. According to Gorgas it breeds principally in yards in more thickly settled parts of the city, in all fresh-water collections, such as rain-water barrels.

_Culex Linneus._ Palpi short, three- or four-jointed in the female, with the last joint usually large; long, three-jointed in the male with the last two joints swollen much as in_Aedes_, or narrower with the last point. Antennae fourteen-jointed; pleure in the female, plumose in the male, where the last two joints are long and thin. Head with narrow curved scales over the occiput and upward forked scales thick on the back of the head, with flat scales on the sides. Thorax with narrow, curved, hair-like or spindle-shaped scales. Scutellum with narrow curved or spindle-shaped scales only. Abdomen with flat scales. Wings (Fig. 3368) with small median scales on the veins and more or less thin linear lateral ones on some or all of the veins. In the wings the first submarginal cell is longer and narrower than the second posterior cell, and the posterior cross vein is always nearer the base of the wing than the mid-vein.

The extreme number of species included within this genus makes it difficult to find one's way even with the aid of a monograph. Here only a few of the most characteristic forms may be briefly mentioned. So far as is known _Culex_ is responsible for the transmission to man of both avian malaria and human malaria. The salt-water or ring-legged mosquito of the Atlantic coast, _Culex solitarius_, is a small gray mosquito with the legs banded in black and white. It breeds abundantly in the brackish swamps of the eastern coast from Florida to Maine. The larvae may be found where the water carries one-fourth more salt than the sea, but it will not breed in fresh water. According to Smith it swarms twenty miles inland and flies occasionally as far as forty miles from its breeding place.

_Culex pungens_ (Fig. 3369) is one of the most abundant and widely distributed species in the United States. It breeds in fresh water exclusively, and its larva are common in watercourses, ditches, hollows in trees, and stumps, in city gutters as well as in transient pools, and in fresh-water swamps. In Havana, Gorgas found it breeding abundantly in cesspools and drains. Its life cycle occupies in summer a minimum of ten days, but its larva may live seven weeks, and adults have been reared from such larvae found frozen in the ice. Further details regarding the genus and some other species of _Culex_ may be found under _Insects_.

Structure and Habits.—Mention should be made of such structural features and such habits as are of special importance in the transmission of disease. The highly modified mouth parts of the mosquito are arranged for piercing and sucking. They consist of the upper lip or labrum (α, Fig. 3370) in the form of a long narrow spine, that is recurved ventrally and expands at its base into a plate-like lamella (α) which lie one of each on either side of the hypopharynx (β), the latter having the form of a delicate blade through the central thickening of which runs a minute canal, and finally the lower lip or labium (γ) which is merely a sheath for the other parts. Giles gives a most vivid description of these structures as follows: "Imagine a surgeon's director, with a piece of thin drainage tube carried against its groove, and with four slender bistouries grouped round it, and you will have a fair working model of the malaria-inoculating apparatus of the mosquito." The upper lip bears at its base a bulb in which are muscle fibres serving as extenso- rors and retractors. Its groove forms somewhat more than a semicircle, and is converted into a complete canal by the flattened hypopharynx lying just below; it is through this canal that blood flows into the mouth cavity. The delicate tube noted above, as piercing the hypopharynx, is the continuation of the salivary duct and through it the salivary secretion, with the "sickle spores" or sporozoites of the malarial parasites, is injected into the vertebrate host, while at the same time the blood of this host is flowing back through the labrum into the digestive cavity of the mosquito. In biting, the mandibles and maxillae appear to cut a passage through the skin by the thrust of the head and the labrum is forced into the wound. While the flexible labium holds together and directs the other parts, its stem being looped down out of the way as the latter proceeds deeper and deeper into the skin.

![Fig. 3368. Wing of _Culex concolor_ (male). To illustrate Terminology. α, Costa; a, auxiliary vein; 1-5, first to sixth longitudinal veins and branches; i, seventh or false transverse vein; I, mesal vein between the hind and subcostal veins; h, humeral transverse vein; s, supernumerary transverse vein; m, middle transverse vein; p, posterior transverse vein; A, costa cell; R, subcostal cell; C, marginal cell; D, anterior fork cell or first submarginal cell; E, second submarginal cell; F, first posterior cell; G, hinder fork or second posterior cell; H, third posterior cell; J, first basal cell; J, second basal cell; K, anal cell; L, anterior cell; M, spurius cell.](image)
The course taken by the spores of the malarial parasite in reaching the new host can be reasonably set down about as outlined above; with the embryonic lariae, however, the case is different and much less satisfactorily explained. These worms are known to bore their way out from the stomach of the mosquito into the muscles and thence through the connective tissue and lymph spaces through which they penetrate, even into the labium which possesses a considerable amount of suitable tissue. Here, in the opinion of Grassi, they produce swelling, and when the organ is sharply bent in biting the delicate covering is ruptured and the worms are set free, to find their way along the mouth parts and into the tissues of the new host. Bancroft maintains that the embryos of *Filario hominë* always escape at the extreme tip of the labium as if a natural orifice existed there. On the other hand, the investigations of Kellogg in Samoa seem to show that the embryos of *Filario Bancrofti* (= *F. magnus hominë*) are liberated from mosquitoes which die and fall into pools of water, and are taken up by the natives in drinking from these pools.

The organism which produces yellow fever has not yet been discovered, and all statements regarding the precise mode of introduction into man by the mosquito are purely conjecture. The interval of twelve days or more which, according to the investigations of the Yellow Fever Commission, must intervene after contamination before the mosquito can carry the infection, shows clearly that the organism of the disease is not merely adherent to the mouth parts of the insect but enters its body and undergoes some part of its life history within the tissues, at the termination of which only is it in condition for transference to a new human host. In many ways it recalls the ease of malarial parasites and a similar method of transference appears probable.

In other cases in which the mosquito acts as a supposed transmitter of diseased germs, the occurrence is more probably only a passive carrying, from one human host to another, of the germs which chance to adhere to the mouth parts. The case cited by Giles and mentioned more in detail below seems to fall into this class.

Though some species are active and annoying during the day, adult mosquitoes are generally nocturnal and active light flyers, shunning the direct rays of the sun, which they cannot endure even for a short period. They hibernate in warm, dark places, and may be found in barns, cellars, and other out-of-the-way spots during the winter. During cool days in summer they do not feed, and their abundance and virulence are clearly related to rainfall and temperature. The natural food of all species is probably plant juices, and the male with rare exceptions does not go beyond this. For experimental purposes, male or female constitute the most acceptable food articles. Even to the female, however, a meal of blood does not seem to be essential to reproduction in spite of the efforts made to obtain it. It was formerly believed that a female mosquito, after having had a single meal of blood, lays her eggs and then dies. Several investigators have recently found that she may survive and bite again either before or after oviposition. It is this occurrence which inoculates man with malaria or yellow fever germs or filariae.

When resting all mosquitoes support themselves on four legs, the last two being held waving in the air; but the posture of the body is sufficiently different to distinguish most forms of the two common genera. *Culex* stands with a noticeable hump, the head and parts forming a decided angle with the thorax and abdomen, which moreover droops, while in *Anopheles* these regions form a single straight line which is oblique or even vertical to the surface on which the mosquito is resting. So far as known, this characteristic holds for all but a single exception (*Anopheles culicifacies* Giles), a species foreign to this continent.

**Life History.**—The female mosquitoes always deposit their eggs in water, and while the precise environment selected by each species is usually characteristic, the general statements made regarding different genera are often misleading. On the other hand, eggs and larve can be found and distinguished with ease. The eggs of *Culex* are deposited in an elongated boat-shaped mass (1, Fig. 3371) about the size and color of a caraway seed. These masses float on the surface until the embryos are hatched. *Anopheles* eggs are deposited singly or in irregular detached groups, and each is provided with a floating organ (7, 8, 9, Fig. 3371) of air chambers to keep it at the surface. The eggs of *Stegomyia* (9, Fig. 3371) are also deposited singly and provided with a floating organ.

According to Carroll, Agramonte, and Lazear, they may be held dry for a month and yet develop when brought into water again.

The larve of all mosquitoes, familiarly known as "wrigglers," float at the surface for respiratory purposes, and if they leave this position it is only for a short time. Those of *Culex* possess a very large head, a long respiratory siphon, and long head downward at a considerable angle with the surface (Fig. 3372). *Stegomyia* larve assume nearly the same position, though somewhat more nearly transverse since the respiratory tube is shorter.

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Fig. 3370.—*Culex panguen*. Female above, male below. Enlarged. (After Howard, Bull. United States Dep. Ag.)

Fig. 3371.—*Stegomyia.* A. Male, b, head; c, proboscis; d, antennæ; e, proboscis sheath; f, labrum; g, mandible; h, maxillæ; i, labium; j, hypopharynx; k, maxillæ; l, maxillary palp; m, basal joint of maxillæ. (Paired organs represented by left member only.) (After Giles.)
Mosquitoes.

The position assumed by *Anopheles* larvae, however, is strikingly horizontal (Fig. 3873) and close to the surface. These larvae have a small head, no siphon, and the respiratory orifices are almost level with the back. The head, which is held barely below the surface, has been turned on the neck through a half-circle so that its lower aspect looks upward as it feeds on the floating débris. The pupa (Fig. 3874, A and B) are also different for the different genera. In all, however, they float at the surface, taking no food but obtaining air through a curious antricate respiratory siphon, until ready for the emergence of the perfect insect, which occurs through the back of the pupal thorax; the pupal skin floats at the surface as a rest for the adult before the latter starts on its initial flight. The process of breeding is retarded by colder weather, and the larvae may even be frozen in masses of ice, and yet after thawing out regain their activity. Many, doubtless, regularly pass the winter in this way in higher latitudes.

**Diseases Transmitted by Mosquitoes.**—There no longer exists a reasonable doubt that malarial disease is transmitted by the agency of mosquitoes. The painstaking elucidation of the life cycle of the haematozoon of malaria has demonstrated the existence of a sexual phase in the life history which takes place in the body of the mosquito and alternates with asexual generation found in human blood. (For further detail on the life history of this organism and its relation to the disease see article on *Plasmodium malariae*). When Manson had a number of *Anopheles*, which had bitten a patient suffering from tertian ague in Italy, brought to England and there permitted them to bite two healthy students, who at a suitable time thereafter came down with malarial fever and showed the characteristic parasites of tertian ague in the blood, all objection to the possibility of this method of transmission of the disease was eliminated. Thus far no one has been able to find any other method of transference save by operative interference, and to judge from the life history of other parasites which manifest alternation of generations in different hosts no other method is at all probable, as Giles has so forcibly and logically demonstrated. It would, however, be hazardous to maintain that the asexual generation, even of the so-called human malarial parasites, may not be found also in other vertebrates. The immediate and abundant appearance of malaria among travellers in regions which have been depopulated or in which man is at best very rare, points indeed to the existence of another host for the asexual generation. On the other hand the sexual generation is known to inhabit only mosquitoes of the genus *Anopheles*, and experiments to infect various species of *Culex* or other genera have thus far proved futile. All data thus far obtained show not only that, given *Anopheles*, the possibility of malaria exists, dependent to some extent no doubt upon other factors, but also that "no *Anopheles*, no malaria" is equally certain.

The relation of the mosquito to elephantiasis (q. e.) and dysentery (see *Neotoma*) has been equally definitely established. Here the mosquito draws the embryo worms, still surrounded by a delicate embryonic membrane, with the blood into its stomach. The embryos bore their way thence into the muscles and after a brief stay wander out into the labium. As in malaria and yellow fever there also a stage of incubation, but unlike the former it is not a period of reproduction for the parasites but merely for the growth of the larvae which are ready to be transferred to the human host when the mosquito has digested its first meal and is ready for the second. In this case certain species both of *Culex* and of *Anopheles* have been shown to afford proper environment for the development of the young worms. The recent brilliant discoveries of the Yellow Fever Commission have demonstrated that the mosquito serves as the intermediate host for the parasite of yellow fever, and that this parasite is transmitted after an interval of approximately twelve days to non-immune individuals by a mosquito that has fed on the blood of a yellow-fever patient. It is the more striking that this mode of propagation has been definitely determined since the specific cause of the disease is as yet undiscovered. The mosquito responsible for the transmission of yellow fever is *Steopagia fasciata*, although in all probability the culpability is shared by other species of the genus, if not by other genera.
Recently Blanchard has summarized forcibly arguments to show that leprosy also is transmitted by mosquitoes. An ailment exclusively human, caused by a bacillus which grows only so far as known in human tissue and which cannot be transmitted by mere contact, the intervention of a biting insect appears indispensable that the bacilli may be brought into a favorable environment.

That the rôle is assumed by the mosquito rests only on conjectural and yet very probable grounds. It has also been conjectured that tubercle bacilli are transmitted by mosquitoes, without positive evidence having been found for the view. While such unconfirmed suppositions must be regarded with suspicion, it is certain that in some instances bacillæ are transmitted by mosquitoes. This is clearly shown by the observations of Giles on cattle to so much that had "sapped for treatment on account of their faces being so swollen that they could scarcely open their eyes, and the fact that such cases are specially apt to occur among patients lying in a surgical ward makes it probable that the unusual effect of the bites in such cases is due to the mosquitoes having indulged in a previous feed from some wound secretion.

In this connection mention should be made of the annoyance caused by mosquitoes, of the irritation due to their bites, very noticeable in some persons, and of the limitation which these disturbances put upon the enjoyment and full utilization of the opportunities for invigorating outdoor existence which the warmer part of the year affords and the health of every individual demands. While trivial perhaps in the individual instance, it amounts in large numbers to so much that for its remedy alone the severest measures against these pests should be adopted. When the loss of life and economic disturbance produced by yellow fever, and the still more serious but less striking since prolonged effects of malaria are taken into consideration, abundant reason exists for the immediate action of civilized communities to abate the mosquito nuisance. It must also be borne in mind that the casual introduction of a case of malaria, yellow fever, or elephantiasis into an otherwise healthy region gives conditions which may lead to the spread of the malady, if the place happens to be infested with the proper mosquito.

Disposal of mosquitoes.—The agency of mosquitoes in transmitting disease necessitates a considerable detail in the means which bring about the disposal of the insects. In general, mosquitoes are not very troublesome and whenever possible, it is true of Culex it is even more characteristic of Anopheles. This was able to find no case in which the distance from the infected house to the breeding-ground of this species was greater than one hundred and fifty yards. *Sumpungua* is said by Gorgas to be a very domestic mosquito, seldom leaving the immediate neighborhood of the place of its birth. The cause of a mosquito plague is then strictly local, although Smith thinks that swarms of the salt-water mosquito, *Culex sollicitans*, may be carried twenty or even forty miles by a favorable wind. In most cases, however, it is clear that natural agents do not disperse them so widely. Howard has given numerous cases of their introduction into new regions by railway trains, and Grass furnishes equally good evidence of their transportation by stage coaches.

Some observations have been made on the rôle of vessels in carrying mosquitoes from port to port. The insects probably are transported long distances in sheltered parts of the vessels and will breed in water barrels, and perhaps even in bilge water, during a voyage, thus furnishing a constant supply of adults. The emergence of mosquitoes from concealment on board ship would serve to explain the sudden outbreak of yellow fever at considerable intervals after leaving port. Ships coming into harbor have recorded swarms of mosquitoes carried out ten or even twenty miles by gentle offshore winds. In this way vessels anchored at a considerable distance from infected ports, or even passing them without having had any direct communication, are subject to contamination with diseases transmitted by mosquitoes.

Prophylaxis.—In view of the part played by the mosquito in the transmission of disease, it is fitting to inquire in the next place what means are available for the correction of the evil. A number of methods have been suggested which differ somewhat in applicability and efficacy, but all of which are valuable in certain cases. First may be mentioned the protection of individuals against the bites of the mosquito. This is accomplished by means of protecting the house with screens of mosquito netting or fine wire gauze in both doors and windows, or by screening beds with curtains of fine gauze, which completely shield the sleeper from the attack of the insect. In the case of persons engaged in outdoor employment it is necessary also to adopt some type of protection for the exposed parts of the body, such as wearing gloves on the hands and hoods or veils of netting over the face and neck.

The results of this practice are, that those in good health are not infected with the parasites carried by the mosquito, and on the other hand that sufferers from the disease do not give infection to the mosquitoes of the neighborhood. In the latter case it is imperative that such should not become sources of infection for the entire neighborhood, and the spread of the infection may be prevented by timely and perfect protection of the invalid from the attacks of mosquitoes. It is reasonable to require that all cases of malaria, as well as yellow fever and other infectious diseases, should be reported to the public health officer and that the isolation of the patient from mosquitoes be rigorously carried out, for otherwise the introduction of a single case may be the source of infection for an entire neighborhood. This has repeatedly been seen within recent times, as when, by the return of soldiers from the Spanish war, a previously unin-
fected neighborhood has been infected with a veritable epidemic of malaria.

This method has been successfully employed among the long-range types of fogging. In Ross's and Gratz's formidable results so pronounced that the latter has proclaimed the possibility of freeing Italy entirely from malaria within a short time and making the most dreaded regions into health resorts. Under protection from mosquitoes, house epidemics of malaria ceased and convulsions were as easy at home as with change of air. Outside of the protected houses hardly a person escaped the disease; within them hardly any one was infected. Such mechanical prophylaxis is of the greatest advantage, particularly to those whose occupation compels them to remain in a badly infected region. But it is after all a temporary measure and unattainable for a large part of the population of the world and under the conditions of tropical climates.

As protection against the bite of the mosquito, use has also been made of their repugnance to strong odors with incense success. The essential oils of lavender, citronella, and eucalyptus are effective, when rubbed on the skin, in discouraging the attacks of mosquitoes; but the greatest success has been attained with the formula: cedar oil, 3 1.; alcohol, 3 1.; oil of lavender, 3 1. As a remedy for the irritating effects of the bites so noticeable on some persons, glycerin, alcohol, and indigo have been recommended. This mixture of iodine is best where the location of the bite does not inhibit its use, and is successful in the worst cases.

It has also been suggested by Koch that the generous and universal use of quinine would destroy the malarial organisms and that we do away with the disease may be doubted whether even under governmental support such a method could be sufficiently generally applied, in spite of the prejudices of a considerable part of the population, in temperate regions at least, even to apartment houses. The property of knots from the exposure of inhospitable spots on the face under the sun may be in favor among the educated part of the population of malarial regions and with travelers who are called upon to penetrate fever-ridden territory. Its sale at cost under government authority is a wise measure for the sanitary improvement of general health in the tropical colonies. In temperate regions many cases of malaria are not recognized as such; and it should be noted, moreover, that while affecting a most important element of the mosquito problem, the proposed method does not offer any solution for the other factors concerned.

The destruction of mosquitoes in the adult condition may be brought about by various means. In order to control the disease effectually by the destruction of the mosquito, the most convenient is, as the protection of the sick against the bites of the mosquitoes. Most convenient of all is the burning of pyrethrum powder, although chlorine gas, formol vapor, chloral, and sulphur may be used with success also. The natural enemies of the adult mosquito are not rare, but it seems impracticable to hope to reduce noticeably the numbers of the insect by the multiplication of its enemies.

A more successful point of attack is offered by the immature larvae and pupae together with their breeding places. The large majority of the latter are not essential and many of them are indeed accidental collections of water, so that the most radical as well as the most effectual treatment of the subject is the abolition of such breeding places. The destruction of mosquito brigades and the thorough examination and treatment of a region. This consists in the destruction of all unnecessary breeding spots and the regular treatment of drains in which they may be found. The insects are here destroyed in their larval stage, and not by causing general health by producing swarms of the insect. It is perfectly practicable in this manner to remove the sources of the infection and to reduce to the minimum limit the mosquitoes in any locality, since, as has already been pointed out, these insects are hoarders and are rarely found at a considerable distance from their breeding places.

For a work of this character there are necessary: first, accurate knowledge regarding the location, number, and extent of the breeding places; second, capable treatment of the destruction of the mosquito may rest in the water even when it rains; and third, a scientific plan for handling the larger water areas that they may not serve for the production of mosquitoes. The smaller pools can usually be filled by draining by deepening the outlet without any noticeable expense. The efficiency and effectiveness of such drainage work are entirely unappreciated, and the removal of a few small pools by draining or filling will often completely abate the mosquito nuisance in a given locality. Larger bodies of water require the clearing away of marsh plants at the margin and the introduction of fish, such as the stickleback, sunfish, and goldfish, which are natural enemies of the larva. A most admirable example of the proper method for the treatment of the problem is given in the report on plans for the extermination of mosquitoes on the north shore of Long Island.

In many cases the most useful and successful method for the destruction of larval mosquitoes is the use of kerosene which has been suggested by Howard and has been successfully employed in many cases. The kerosene spreads over the surface and forms a film which smothers the larva and pupa and catches the females as they come to deposit eggs. For the petrolyzation of a tank, what is experience shows that the introduction of oxygen is best where the location of the bite does not inhibit its use, and is successful in the worst cases.

The destruction of the mosquitoes and their breeding places has attracted much attention recently. The responsibility of the individual for the maintenance of his health and the diseases of his environment is thoroughly recognized and the breeding of mosquitoes will soon be included as a nuisance everywhere as it has been in several places, notably Havana, of which Ross speaks with admiration, commending "the straight-thinking Americans who quickly fine a person who breeds mosquitoes." That campaigns against mosquitoes are not only reasonable but eminently successful has been abundantly proved by work in many localities in the United States under the direction of Howard and others, by the work of Young in Hong Kong, of the United States Army in Cuba, the most striking of all by the campaign of Gorgas in Havana. Within ninety days after the adoption of regulations providing for the effectual isolation of the sick and for the destruction of mosquito breeding places, a town was declared free from malaria by Howard and has remained free ever since. The destruction of the larva in the uninfected and neighboring houses was successful; and in the entire town. Havana was freed from yellow fever; and in spite of repeated introduction of the disease from without, the death rate from yellow fever, which had averaged four hundred and sixty-two annually for ten years previous, was reduced to a total of five in 1901, and for malaria the reduction was from about three hundred and fifty in 1900 to only twenty-six for the first four months of 1902.

Results.—Finally it is proper to call to mind the effects which will be produced by the extermination of the mosquito. These evidently depend upon the character of the diseases. Yellow fever consists of a single illness followed by greater or less humanity from subsequent attacks; consequently the extermination of the mosquito will bring about the complete disappearance of the disease. This has been the case in Havana. Elephantiasis and malaria, however, are protracted diseases. The parasites remain alive for years after the time of introduction by the mosquito. In the case of the latter the symptoms of the disease, and in malaria relapses occur long after the removal of the affecting agent; hence the disappearance of all mosquitoes in a locality those persons who were previously infected will continue to suffer from these two diseases, so that not much change may be found within a period of several years. And yet a single year's work in mosquito extermination in Havana reduced the mortality
from malaria in that city ninety-three per cent. within eighteen months.

In consideration of the enormous losses which Celli sums up for a single country in the positive assertion that "malaria costs Italy annually thousands of lives and incalculable treasure," and in view of the even greater losses of other countries, it is not too much to hope that extended action may soon be taken through governmental agency for the correction of the evil by the eradication of the mosquito.

Henry B. Ward.

Principal Works Consulted.


END OF VOLUME V.
Nematoda
pneumeral clampsia, tuberculosis, toxemia of burns, etc. The foci are found chiefly in the liver, spleen, lymph glands, and kidneys. The formation of the necrosis is uniform in all the regions in which it is found. The necrosis is due to the death of cells in the affected regions. The material of the necrosis is not visible to the naked eye, or they may resemble miliary tubercles or abscesses, for which they may be mistaken. At other times they may appear as small pale yellow or grayish spots barely distinguishable from the surrounding normal tissue. Microscopically, small islands of simple congelation or caseation necroses are found. When the necrosis has been recent, diffuse or fragmented chromatin may be present in the areas of necrosis, or may stain in the necrotic areas there is often a leucocyte infiltration. Many of the leucocytes become involved in the necrotic process; their chromatin becomes diffuse, giving rise to a deeply staining periphery. In the liver focal necroses are often limited to the central zone of the lobule about the central vein; hence the designation central necrosis. The same term is also applied to central necroses of bone. Focal necroses are due to the direct action of bacilli or to poisons acting directly upon the cells or to local asphyxia. The changes in the small capillaries of the affected tissue play a very important part. Fibrin may be first formed in the capillaries and lymph vessels, and thus shutting off the supply of nutrition cause cell death. In other cases changes in the capillary walls may be first produced by the inflammatory agent; capillary thrombosis following this, the cellular necrosis may be secondary. Transudation of serum through the injured capillary walls may also lead to necrosis of the surrounding cells. The sequence of focal necrosis are the same as those of necrosis in general.

FAT NECROSIS.—The necrosis of the fat-containing cells of adipose tissue forms a condition so striking in its clinical and pathological aspects as to warrant special mention. The condition occurs most frequently in the abdomen and in connection with pancreatitis. The necrotic areas appear in the fat as grayish or yellowish, or in some cases black, opaque areas, soft or gritty, slightly elevated and usually circular in outline. The appearance sometimes is such as to suggest that the fat had been seared by a hot iron. Microscopically, the fat cells are enlarged, the nuclei absent, the contents granular or presenting the appearance of fine needles radiating from the centre of the cell. Onset acid has no effect upon the altered fat cell. Changes in the small capillaries of the affected fat tissue are in a variety of ways. The granular detritus in the fat cells consists of a combination of lime salts and fatty acids. If the process is old, the amount of lime salts may be great. It has been definitely shown that fat necrosis is due to a specific cause, the disease occurring only under certain inflammatory conditions of the organ that gains access to the tissues through the blood or lymph. Experimentally, fat necrosis may be produced by injection of pancreatic extract, by ligation of the pancreatic vessels, by introduction of pieces of pancreas into adipose tissue or into the peritoneal cavity, and by the direct action of steapsin in fat tissue. Not only may the abdominal fat be affected in cases of pancreatitis associated with fat necrosis, but also the fat of the periumbilical, liver cells, retrolental region, and bone marrow. In the majority of cases the condition is fatal, but recovery has been noted, the dead fat cells becoming calcified.

DECOMPOSITION, the disintegration of the red blood cells, and leucopenia, the disintegration of leucocytes, are discussed by authors who consider caseous necrosis. The process in nature of these processes is not at present definitely determined. Bacterial products, various poisons, the blood sera of animals of different species, or of the same species under certain conditions, are the chief factors in the production of these conditions. Normal hemorrhage occurs in the spleen, lymph glands, hemolymph glands, and bone marrow. In pernicious anemia, sepsis, and many of the acute infectious and intoxication hemorrhages occur in these organs to a greatly increased extent. Pathological destruction of the red cells in the circulating blood occurs also in a variety of infections and intoxications. The term leucopenia is more properly applied to this condition, but has been largely superseded by the word leukopenia and leukocytosis.

Sequestrum of Necrosis. — The course of the necrotic process depends upon the anatomical nature and location of the affected tissue, the course and manner of the injuries influence causing the necrosis, the condition and environment of the affected part, the vascular condition, and lymph, the nature of preceding changes, the opportunity for the access of air and pus-forming agents to the part, etc. About the necrotic area there is always a more or less marked inflammatory reaction in the surrounding healthy tissue. As a result of such inflammation the necrotic area becomes isolated and sequestrated. The process is called sequestration, and the area of necrotic tissue so shut off a sequestrum. The ultimate sequelae will be: (1) regeneration following the absorption or casting off of the dead tissue, new tissue resembling the normal being formed; (2) calcification; (3) coalescence; (4) cyst formation, the dead tissue being liquefied and encapsulated; (5) chronic abscess or ulcer.

Necrosis of Bone. See Bone, Pathology of.

Nematoda.—The class of the Nematoda or round worms constitutes a large, rather uniform, and distinctly demarcated group, which by many recent authors has been regarded as of the rank even of a phylum, in which case the name Nematolophien has been applied. The group is characterized by a cylindrical body, often filiform even in its attenuation, and by the heavy cuticular investment which carries in some cases small bristles, hooks, or spines, but which is consistently without appendages and manifest at most surface striation, but never true segmentation. The body cavity is extensive, but unprovided with a peritoneal epithelium, and the sexual and excretory systems do not stand in any connection with it. Another striking feature is the entire absence of cilia in all stages of development.

An alimentary canal is present, at least in some stage of the life history of all forms. It is with rare exceptions a permanent structure in the members of the sub-class of true round worms, or Eunematoda; but in the sub-class of the hirudinises or Gordiaceae, the alimentary canal is greatly reduced in the adult, in that the month is closed and a delicate solid string of tissue is the only vestige of the anterior portion of the canal. The posterior region still retains its cavity and functions in connection with the reproductive organs of the sexes, which in many cases it is a common outlet. In the Eunematoda, on the other hand, the male organs join the alimentary canal to form a common cloaca, but the female system is entirely unconnected with the alimentary system, and the vulva occupies a variable position in the midventral line. The sexes are separate, though in rare instances parthenogenesis or hermaphroditism modifies the usual balance.

By far the largest number of forms belongs to the Eunematoda, which will be considered first, while the Gordiacean and, as an appendix, the Anomocephalides will be discussed subsequently. Among the Eunematoda the better known forms are parasitic, though some are free living and an occasional species is capable of making use of both types of environment. The free living species are uniformly insignificant in size, but among parasitic forms one finds the microscopic blood parasites and the much larger guinea worm. In respect to location also there obtains great variety; and one finds these parasites in all parts of the alimentary, respiratory, circulatory, excretory, and muscular systems. The parasitic forms are of the greatest interest, and it is one of the difficulties of the study of parasites.

The greatly elongated cylindrical form tapers as a rule more or less toward both ends, though generally speak-
ing the head is truncated and the tail acute. The chitin-
ous cuticula invests the entire body, and is introverted a
short distance at all orifices. It bears rarely un-
jointed spines and bristles and is marked often by delicate sur-
face striations. In cross section (Fig. 3335) the body ap-
pears circular, and shows beneath the cuticula a thin hypoderm-
us layer, which is prominently thickened at four points. Of
these the lateral lines, fields, or areas, as they are called, are
largest, and are visible in surface view as delicate longitudi-
nal stripes (Fig. 3335). The dorsal and ventral median lines are
much less prominent and are distinguishable ordinarily only in sectional views.

Directly below the hypo-
derma is the muscular layer which is inter-
rupted by the lines already noted, and hence appears as four muscular fields. The muscle cells
(m, Fig. 3336) are of a peculiar type in that a pro-
toplasmic body is distinct from the contractile fibrillar port.

The main trunks of the nervous sys-
tem occupy the dorsal and ven-
tral areas, while the lateral areas
contain each a
delicate canal, which has been interpreted as part of the otherwise unexplained excretory system; with the latter
are associated, however, certain stellate cells of peculiar
character, which project from the lateral fields into the body cavity and are known as phagoctytic organs.

The alimentary canal (q, Fig. 3335) is a straight simple tube extending from the mouth, which is always terminal, to the anus, which varies in location from the posterior
canal to a position on the anterior surface, some little distance removed from it. Various features connected with the canal are of great systematic importance. About the
mouth are found a number of lips and papillae characteristic of the genus or family. The buccal or pharyngeal
cavity, an enlargement at the outset, the muscular oesopha-
gus with a triangular lumen (Fig. 3337) and a ter-
ninal enlargement which may be indistinctly marked, or may partake of the form of a distinct bulb, or even two
such, with a valvular apparatus, the intes-
tine proper followed by the rectum and cloaca in the male—these constitute the distinct parts of the alimentary
system.

The sexual organs have the form of a long coiled tube, in the attenuated distal end of which the sexual cells are pro-
duced, while the proximal portions afford storage for the perfected gametes before they are discharged from the body. In the female the system is regu-
larly bifid, although one horn of the uterus may be undeveloped to a greater or less extent, while in the male only a single tube is present. The varied
development of the system in the two sexes has already been noted. About the vulva chitinous lips often of notable
thickness are developed, and on the ex-
ternal surface near the male orifice nu-
merous papillae characteristic of the genus or species, and at times a sucker also are to be found; these function as accessory copulatory apparatus. In the same category are included ex-

doing folds of the body wall known as the bursa and awl-shaped chitinous structures called spicules. The bursa varies from a pair of simple folds lateral to the cloaca to a cup or bell surrounding it and the posterior end of the body. The spicules, either one or two in number, with an accessory guiding piece in some in-
stances, are developed in a dorsal evagination from the cloidal wall and provided with special musculature for extrusion and retraction. Their form varies greatly in different species, and with the bursa and circumal
papillae constitutes the means for determination of the spe-
cies.

The Eunematoda are oviparous, but in some cases the eggs are retained long enough in the uterus to contain when laid a partly or fully developed embryo; and in a

Fig. 3335.—Internal Anatomy of Ascaris lum-
bricoides, opened along dorsal line. A, Male; B,
Female; c, lateral line; de, ductus excretorius; do, uterina; e, intestine; eo, esophag-
gus; or, ovary; ov, vagina; ve, seminal vesicle. (After Delafond.)

Fig. 3337.—Section of Ascaris lumbricoides at level of oesopha-
gus. c, Cuticula; h, hypoderm; i, intestine; m, muscle layer; s,
dorsal, a, lateral, r, ventral lines; w, excretory canal. (After Hertwig.)

Few species the embryo deserts the shell before it is ex-
truded from the body. All stages in the development of this ovoviviparous habit may be observed.

Ordinarily the eggs which undergo development exter-
REFERENCES HANDBOOK OF THE MEDICAL SCIENCES.

Nematoda.

Anguillula aceti. A. Tail of mature parasite; sp, spicules. B. Spicules partially protruded from anus, Magnified. (After Stiles.)

FIG. 378. — Anguillula aceti. A, Tail of mature parasite; sp, spicules. B, Spicules partially protruded from anus, Magnified. (After Stiles.)

The living specimens develop directly, i.e., without a change of host, though a certain period of larval life is necessary. Some species develop directly in method of reproduction. In one case a larva (Trichinella) the entire life history is passed within the host and transportation to a new host depends upon the carnivorous habit. In other cases also (blood fluke) the life history is passed within two hosts and no part takes place externally; but in most instances there is a free living stage and infection is brought about primarily through the drinking-water. Some prominent exceptions to this general statement are noted later.

The family of Anguillulidae, which is difficult to characterize, contains many nematodes of small size, transparent, filiform, and tapering to both ends. The esophagus is inflated or has one or two bulbs at the posterior end. The female possesses double symmetrical uteri and short reflexed tubular ovaries, with vulva at or behind the centre of the body, with few, large eggs, and with development rapid, often ovoliviparous. The male has two equal chitinious spicules, with or without one or more accessory pieces. The type genus is Anguillula Ehrenberg 1836. — Buccal cavity very minute; esophagus cylindrical with two bulbs, the posterior having a valve apparatus; vulva behind centre of body; male without bursa; accessory piece single, fan-shaped. The best-known species is the vinegar eel, which has recently been found as a parasite of man.

Anguillula aceti Müller (Fig. 338). — Cuticula unstriated, body tapering slightly anteriorly; tail greatly attenuated. Male 1.35 to 1.45 mm. long by 24-28 μ wide. Spicules 38 μ long, similar, twisted; accessory piece slightly caudal; no bursa; papillae at least two preanal and one postanal. Female, 1 to 2.4 mm. long, by 40-72 μ in diameter, contains embryos 0.22 mm. long by 12 μ in diameter.

This worm, which is everywhere common in vinegar, has been recently studied by Sillès and Frankland in the role of a human parasite. The specimens were taken in great numbers from the urine of a female patient, and were present during a period of thirty-three days. The urine was always very acid and once had a marked odor of vinegar. In this specimen the worms lived two months, and individuals then removed to vinegar became vigorous and bred rapidly.

Pathology. — The patient had chronic parenchymatous nephritis of a degenerative type, and the urine frequently contained albumin, but not while the parasites were present. No symptoms traceable to them were observed, and their presence in the bladder remained unexplained. The suspected use of vaginal douches anointed with vinegar was denied by the patient, and no grounds existed for questioning the truth of the statement. Evidently this parasite might be present in the vagina if such a practice were followed. Billings and Miller have reported two other cases from the United States in which, however, the source of the parasite was not demonstrated beyond question.

Leptodera A. Schneider 1866. — Gophagus with two bulbs, the posterior with or without valves. Male with or without bursa, often six to ten papillae on the bursa or on the median line; two short spicules and a single acetabulum are characteristic. Some species are hermaphroditic. A somewhat indistinct genus, difficult to separate from that last described, and perhaps identical with it.

Leptodera Nielly R. Blanchard 1885. — (Syn.: Anguillula leptodera Nielly; Rhodotyphus Nielly R. Blanchard.)

This species is known only in the larval form, in which it measures 333 μ in length and 13 μ in breadth. The alimentary canal was the only internal organ described; it displayed two enlargements in the pharynx, the second pharyngeal bulb having a dentate armature.

The worms were discovered by Nielly in 1882 in a young man, fourteen years of age, who was born near Brest, and had never been out of that region. A dermal eruption, much like cra-craw, of about five or six weeks' standing, affected chiefly the patient's limbs. In the fluid of each papule were found several worms, and the blood showed on microscopical examination at the outset of the malady many small nematoda, which, however, could not be found later; at no time were they found in faces or urine.

The method of the introduction of the parasite was unknown; but it was remarked that the lad had been in the habit of drinking from brooks. It is easily surmised that the eggs of the worm were swallowed in drinking, and that the embryos, hatching out in the alimentary canal, followed their way into the circulation and thus reached the skin. Their presence both in the blood and in the papules is thus easily explained. They have been found in the skin, larval nematoda having been observed in dog, fox and horse in Europe by many investigators.

In this connection it is important to note the similarity of this case to cra-craw, acontious vesicular eruption of the skin, observed in Africa and in South America, in which various investigators have reported the presence of larval nematoda. Manual application of cra-craw as a dermatitis characteristic of the "sleeping sickness," endemic on the west coast of Africa. Menez has suggested that the parasites to which this case is due may have been imported by some sailor from Africa, and associates it with the case of elephantiasis, also observed in Africa.

Leptodera pelio (A. Schneider 1866). — (Syn.: Rhodotyphus pelio A. Schneider 1866; R. pelio Bluntsch 1873; R. genitalis Schelber 1889.)

Male: Length, 0.8-1.5 mm.; bursa with seven to ten ribs on each side; spicules 27-38 μ in length, nearly alike.

Female: Length, 0.9-1.3 mm., posterior extremity long.

FIG. 339. — Strongyloides stercoralis from Human Intestine. X 80. (After Braum.)

Fig. 339. — Strongyloides stercoralis from Human Intestine. X 80. (After Braum.)
and pointed, vulva a little in front of the middle; ovary not paired; eggs oval, 60 by 85 μ.

Scheiber found this species at Stuhlweissenburg, Hungary, in the urine of a native woman suffering from pyelonephritis, pneumonia, and acute intestinal catarrh. In the urine, the illness the worms were found in the vagina in all stages of development. Several other authors have found what is closely related, if not the same, in the urine in cases of hematuria; but the parasitism is probably accidental, since Oerley has shown that L. genitalis Scheiber resembles L. pellito, a common free living form found in moist earth and putrefying substances, and also that worms of this species will multiply in the vagina of white rats. There is further to be noted both the habit of Hungarian peasants in employing moist earth for putteaces and the record of Scheiber, that patient and clothing were washed, thereby killing altogether likely that such a putteice had been applied near the vulva, and that from it the free living worms had successfully colonised the vagina.

Leptodera terricola (Dujardin 1845).—(Syn.: Rhabditis terricola Duj. 1845; Pelodera teres Schneiker 1866; P. setigera Bastian 1879; R. carinata, Cusholl 1879.)

Mouth with six lips, anterior bulb of pharynx fusiform, posterior spherical. Male: Length, 1.3 mm.; tail attenuated, slightly longer than the body. Female: male: 2 mm. In length and over; posterior exterior sometimes regularly attenuated, sometimes sharply rounded and provided with a very fine tail; vulva about the middle of the body; ovoviviparous; eggs 60 by 40 μ.

This typical free living species should be listed as a pseudo-parasite of man by virtue of its occurrence in cadavers, and, in one case at least, its confusion with trichina. The facts in this celebrated case are as follows: The English school ship Corwall was visited in 1879 by an epidemic which affected many cadets and killed one. The symptoms of the disease were not incompatible with trichinosis, and macroscopic examination of the examined cadaver, undertaken two mouths later, demonstrated in the muscles of the abdomen, which, with the exception of the first one examined, were dead, but not one was encysted. The epidemic was pronounced therewith trichinosis, and attracted enough attention to be brought before Parliament. Cusholl and Bastian easily showed that the worms in question had nothing to do with Enterobius, and Oerley established their identity with L. terricola, which had undoubtedly penetrated the body after inhumation.

The family of the Angiostomidae includes small rhabditid-like nematodes which marine ichthyophagus, and with the alternation of two types of sexual generations of which the first is dioecious, free and very similar to Leptodera, while the second is parasitic, hemparaphidote, and of a different structure.

Strongylodes Grassi 1879.—Parasitic generation with simple mouth in which no armature is present; cylindrical pharynx very long. Free generation with small oral cavity; pharynx with two bulbs, the anterior fusiform, the posterior spherical and armed; male with two small spicules similar.

Strongylodes stercoralis Stiles and Hassall 1902.—(Syn.: Anguilluloides intestinalis and A. stercoralis Bayvay 1877; Leptodera intestinalis and L. stercoralis Cusholl 1879; Pseudorhabditis intestinalis Fornocchi 1881; Rhadincola

Strongylodes Leneck 1888; Strongylodes intestinale Grassi 1888; R. intestinale Blanchard 1885.)

Free generation (Bayvay's A. stercoralis) both sexes occur; body slender, tapering toward the ends; mouth with three to four distinct papillae; esophagus 0.16 mm. long, with well-developed cavity and two bulbs, the posterior of which is armed with three chitinous teeth; anus with protruding lips on right side of body. Male (Fig. 3542, B); 0.75 to 1 mm. long, 35 to 60 μ thick, with short recurved tail and two curved, conical spicles, 35 μ long. Female (Fig. 3541, A); 1.14 mm. long, 30 to 35 μ broad, with long slender pointed tail; vulva a little behind the middle of the body and on the right side; uterus double; eggs ellipsoid, thin-shelled, 70 by 45 μ; segmentation ad referred to embryo often hatched within body of mother; embryo at first with very pronounced esophagus, and chitinous teeth, soon changing to flariform stage.

Parasitic generation (Bayvay's A. intestinalis) (Fig. 3530) in cadavers, and also as stages of the life histogenetic; length 2.1 to 2.2 mm., breadth 39 to 40 μ, body slightly tapering anteriorly, but terminated posteriorly by a short bluntly conical tail, with rounded and slightly dilated tip; mouth with three poorly developed lips (or none). Strongly-stained, with short spicles, one-fourth the length of the body or more, distinguishable readily only in color from the intestine; vulva transverse in posterior third of the body; uter with five to six (nine to twelve?) ellipsoid eggs, 30 to 35, or 35 to 45 μ by 20 to 23, or 23 μ, and often joined in strings of two or three. The eggs are segmenting when laid, they develop rapidly and hatch before being ejected with the excrement. Embryos phalidiform, 0.3 to 0.6 mm. long, by 16 to 21 μ wide; first molt within twenty hours, if in infective state.

Dr. Normand discovered the species in 1876, when examining microscopically the stools of soldiers returned from Cochini China, who were suffering from acute dysentery. Some months later he found at the necropsy of a soldier who had died from Cochini fever, the other form of the species. Both of these forms were originally studied and described by Bayvay. It was in 1888, before the connection of the two was established by Leucart, who showed that the two phases were of the same species. In life man harbors in the canal the one* form (L. intestinalis Bayvay) and its young which, reaching the exterior with the faces, may be transformed then into the other adult (A. stercoralis Bayvay); the latter transformed stage may also take place in the body of the host; death, as in cultures made in confirming these discoveries. Later authors have added many details, which may be summarized as follows:

The parasitic generation, which recalls a strongylid or a filariid in structure, produces eggs so abundantly that from an ordinary infection more than a million embryos may be evacuated in a single stool. The embryos (Fig. 3540, A) measure at hatching 0.2 to 0.24 mm. long by 12 μ broad, but develop so rapidly that those in the stools have attained a length of 0.30 to 0.60 mm. by a width of 16 to 23 μ. The embryos are characterized by a rhabditiform esophagus, and under normal temperature they soon moult; and then, protected as if by a cyst in the larval skin, await more favorable conditions for further development. If kept, however, at 25 to 35° C. they develop to sexual maturity in fifteen to eighteen hours; they copulate in thirty hours, and the females begin to lay at fifty to fifty-five hours.

After the first moult the larva from which the embryos becomes more distinct, and one can see three or four oral papillae and a buccal cavity, together with an anterior enlarged and median constricted region of the esophagus, which is terminated by the esophagal bulb, containing an apparatus for trituration composed of three chitinous teeth. The intestine which follows ends in a slightly protruding anus located on the right side. Also

* It is disputed whether the other form may very rarely be found under the same circumstances.
on the right, about one-third the distance from the bulb to the tail, is the whitish lenticular proton of the sexual system.

In most cases studied in temperate regions after a few days in culture, these embryos die or change form, becoming elongate and with more tapering tails, the esophagus loses its teeth and enlargements and becomes a uniform cylinder; the embryos resemble young filariae and have taken on the strongylid form (Bavay's). Only thirty to forty eggs are deposited by each female of the free generation (Bavay's A. stercoralis), which develop so rapidly as to approach the ovoviviparous condition; they hatch out young worms about 0.25 mm. long, in which the esophagus manifests a rhabditiform character. After the first moult, which occurs when they are about 0.35 mm. long, they acquire in from thirty to thirty-six hours the strongylid appearance, that in the mouth shows four lips, the esophagus is cylindrical and has lost its dental armature, the tail is shortened, and bears near its end two small lateral wings. At the end of eight days the free form can no longer be found in the cultures, and all the young have become strongylid larvae. If introduced into the intestine, these larvae develop into the parasitic female, with which the cycle begins anew.

A remarkable modification of this, the normal life cycle of the species, was discovered by Grassi, who found that the development might be abridged by feeding the rhabditiform embryos not directly into the strongylid larva without the intervention of any free sexual generation. This direct development has been confirmed by Leichtenstern, who has observed it for weeks in succession, while at other times alternation with the free rhabditiform generation comes in. The causes of this transformation are unknown as yet; it must, however, be regarded as an important etiological factor, since the infection of man may be due to the accidental introduction of either sort of larve, or of the free rhabditid form. Stiles has suggested that this abbreviation is a step toward perfect parasitism.

The method of introduction can only be inferred to be by pure water or vegetation, some part of which have been contaminated by human excrement. Although Normand acquired infection in Cochín China, while having refrained absolutely from drinking any but imported water, and was accordingly inclined to question the part played by water in its dispersal, yet in the absence of further evidence general considerations must point to this as the most probable source of infection. Differences in manner of development are present in embryos from a single original infection and external conditions seem to be indeterminate; it is possible that the age of the parent animal is of influence. Embryos with direct development are at least more resistant, and alone survive under unfavorable conditions.

It has been claimed after culture experiments by Wilms that there are not two varieties of the parasite, one developing by the direct, the other by the indirect method, but that the embryos from the same lot of eggs may develop in either fashion. Though the number of cases observed is probably too small for definite conclusions, it is striking that cases infected with the tropical strongylids develop usually with the interpolation of the free sexual generation, while cases infected in temperate regions, both of Europe and America, manifest almost exclusively direct development. It should not be forgotten that there may be concerned here more than one species of closely related and heretofore confused forms, which would account for the apparently conflicting statements. Certain it is that the figures of the larve, given by various authors, do not agree in the form and proportions of the different regions in the esophagus, which for individuals in the same moult are ordinarily regarded as constant rhabditiform types, as figured by two most recent observers, Strong and Braun, shows numerous differences in detail, which can hardly be errors in observation.

The observations of Grassi, that the alternation of genera is not a necessary feature in the life cycle of this species, is still further of importance as explaining the enormous number of worms found in the intestine in some cases. Leuckart records an instance in which prodigious quantities of the worms were evacuated even a year and a half after leaving the body by infection. Such evidence leaves little reasonable doubt of the multiplicity of the parasite in the human alimentary canal, as in fact related species do reproduce in other animals and Strongyloides rhabditis aceti multiplies in the human bladder as noted already.

Distribution.—Strongyloides stercoralis occurs very widely. The entire tropical and subtropical zone of Africa, Asia, the Philippines, and the East Indies form apparently its original home, while the habitats in Europe is all but universal. It has also been recorded from Martinique, Brazil, Hawaii, and in Europe from Sicily, Italy, and Mount St. Gothard tunnel, Spain, Russia, and among brickworkers along the Rhine and in East Prussia. First reported in the United States was a case in a sailor in Baltimore by Thayer, who showed its probable endemic character. For further data on its occurrence as well as for bibliography and discussion of previous cases consult thesplendid paper by the latter author. Stiles has 5 further cases to be published soon.

Pathology.—At first the worm was regarded as the cause of the dysentery in which it was originally discovered and with which it is usually associated; more recent investigations have shown this to be incorrect. The rarity of the worm in the intestine at the outset of the disease, its abundance in stools of convalescents, its absence in cases which have freely bilious diarrhoea, and often in severe attacks of Cochín China diarrhoea, and finally its frequent discovery in the alimentary canals of normal health, all militate against the supposed pathogenic rôle of the species; and both Grassi and Leichtenstern go so far as to proclaim the species entirely innocuous, "innocent commensals of man." On the other hand, its presence is not regarded by all authors as harmless, even though they do not regard it as the cause of the disease. Somnios has found that in Italy excessive multiplication of the species may give rise to acute enteritis followed by dangerous meningitis. Gouëd and others have regarded it as having probably contributed to the production of the supposed pathogenic rôle of the species; and both Grassi and Leichtenstern go so far as to proclaim the species entirely innocuous, "innocent commensals of man."
The female deposits eggs in the galleries of the mucous membrane, 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 subsided with the death of the parasites three days later. More probably this case represents a double infection of *Filaria* with *Strongyloides*. The limited number of *Strongyloides* eggs found in the faeces is to be explained perhaps on their deposition deep in the tissues. Mora mentions that the presence in the faeces 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 not in others. This author believes that the parasite is not harmless, though not particularly dangerous; and he finds it capable of producing an intermittent diarrhoea with intestinal disturbances. It certainly causes some constitutional injury from its rapid movements.

**Prevention.**—The use of filtered or boiled water and abstaining from eating uncooked, raw vegetables of any sort, as well as the destruction of stools from patients afflicated with the parasite, are evident measures suggested by the life history. Special mention has been made of various observers of the hygienic 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 hydroaetic tendency of the embryos is useful in diagnosis in cases in which the differential diagnosis between these species and *Obtura* is not difficult, since in fresh faeces the latter form appears only as eggs, the former only as embryos. The *Obtura* 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, only 3 μ long. If eggs are taken from the canal at a necropsy, those of *Obtura* are distinguishable from those of *Strongyloides* by the smaller size and thicker shell.

**Treatment.**—Turpentine and male form have no apparent effect. In mild cases thyroin 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 *Strongyloides* and *Filaria*, but which is usually included in a separate family of the Gastrotricha, is represented among human parasites by a single rare species: *Gastrostoma minima* (Levinsen 1889).—(Syn.: *Chiarodontus slomaniae* 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, a few days later, from which a 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 *Filaridae*.—Body greatly elongated, filiform, when fresh often papterous, but usually horny or hard and horny to the touch, on the lips even with a buccal capsule; esophagus 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.
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 molts, occupying five or six weeks, they metamorphose into a more cylindrical form with a separate 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.

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, and 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 Decan (India) and on the west coast of Africa, where in 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 Ceylon 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 com-

monly 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. 3544), 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.

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. occi Gerv. et v. Ben., 1839 (nec. v. Nordm. 1852); Dra- cunculus occi Diesing 1860; Dr. loa Cobbold 1864.)

Female 30–40 mm. long, by 0.3 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 25–30 μ, when deposited containing embryos 210–230 μ in length.

Male: 20–30 mm. long, 0.3–0.5 broad; cuticula not striated, but with small papillae except on first and last fifth; mouth without papillae: tail (Fig. 3545) slightly incurved, with lateral wings and five ventral papillae on each side, three below the tip and the first the largest; spicules two, short, unequal.

It was first observed in 1778, 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 noted, 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.

In distribution _F. loa_ is limited to an area on the west coast of Africa (Guinea, Gold Coast, Ashanti, 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 rec-
Nematoda.
Nematoda.
REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

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 was recently 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 osseous or the latter. It is then in the eye by which it acquires its full development.

That unlike F. multilocularis 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 of the body and 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 a new host, or are ingested. Whether the intermediate host is the fish of L. Manson has conjectured that the well-known F. diversa 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 violent pain which may appear 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 edematous 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. Deformities in opening is necessary, and if after cognizance the eye the worm is 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 1839.—Body tapering uniformly, head rounded. Male 30—35 cm. long, 40—140 μ in diameter, tail incurved; one postanal, one 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. oesiniae and F. diversa, 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, a number of 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. conjunctiva Adrarrio 1885.—(Syn.: F. polyphylax Pace 1867, nec Wilson 1844; F. peritoni hominis Buselius 1880; Filaria inermis Grassi 1887.)

Female: Length 10—16 cm., width 0.5 mm.; cuticle striated not embossed or papillate; mouth terminal, unarmed; vulva near anterior end; testis 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 India, Japan, and in a few places in Africa. The species is, according to Grassi, a normal parasite of the horse and ass, and is only occasional in man.

Filaria levii Dying 1851.—(Syn.: Filaria ocelli humani von Nordmann 1822.)

With the exception of some species in the family Filariae severum and F. oesiniae, 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 these cases the intermediate host is Neinatoda. The species is, according to a view, a normal parasite of the horse and ass, and is only occasional in man.

Filaria levii Dying 1850.—Length 14 cm., width at head 0.1 mm., at centre 1.6 mm.; anterior end pointed, posterior blunt; mouth without papille; esophagus 1.15 mm. long.

Passed in West Virginia from the bladder of a man, fifty years of age. The patient had been suffering some days from nematodes in the faeces. A filaria, Railliet, has been named 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 oesophagica Leuckart 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.

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

Filaria pacifica Ponce 1864.—Length 30 mm.; pointed anteriorly; mouth with four papillae, posterior end slightly inflated; vulva in posterior third; uterine double, but in posterior branch rudimentary.

A single specimen only from a postulate on the upper lip of a man in Naples, Italy. Not reported since 1864. F. lymphatica Treutler 1793.—(Syn.: Homatolupus lymphaticus. Treutler 1793; Filaria hominis bronchialis Rud. 1819; F. bonelli Dies. 1851; F. lymphatica Moq.—Tandon 1860; Strongylius bronchialis Colbouch 1879.)

Length about 20 mm.; head widest expanded 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 Brecc and by Zorn, 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 Strongyulus lentiginosus (= S. api), 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 narvalis Leuckart 1856.—Mouth with six papillae. Male 12—18 cm. long, 0.7—0.9 mm. wide; posterior end with long lateral wings and eight preanal as well as nine to ten postanal papillae; posterior end rolled in several turns like a corkscrew, spicules unlike. Female: 25—30
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 Bowley 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.: *Filaria cystica* Salisbury 1868, *Filaria bancrofti* Rud. 1819; *F. magnifica hominis* Lewis 1872; *F. magnum hominum* Son-sino 1874; *F. dermatomaculata* Da Silva Ararito; *F. Wuchereri da Silva Lima 1877; *F. magnifica hominis nocturna* Manson 1891; *F. nocturna* Manson 1891.)

Body elongated, white, opaque, very delicate, showing tendency to coil; cuticles without transverse striation, anterior end slightly thickened, without lips or papille, posterior end rounded. Male 55–60 mm. long; 0.1–0.12 mm. broad; head 51 μ, neck 51 μ in diameter. Oesophagus 0.13 mm. long; tail (Fig. 3547) slightly bent, 1 mm. long; papille undescribed; spicula 0.3 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 0.72–1.57 mm. from head, anus 0.282 mm. from tail. Eggs 35–38 μ or 35 (Lothrop and Pratt) by 13 μ. Embryos 0.127–0.2 mm. (or 0.2–0.38 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 1862 by Demarquay, this form has been very generally confused with other species of the group, especially *F. magnotheca*, and even now only a little can be given beyond the data contained in the general characteristics which are taken from Maltland and Manson’s account, and from that of Lothrop and Pratt. The discrepancies in 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 transverse section much the form of a matelasse 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 filariae 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 (1) 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 quite 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 covered 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.

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 several of the embryos have traversed the wall of the stomach and are in the thoracic muscle. At the end of eleven days they are 20–35 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 larvae are

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**Fig. 3546.—*Filaria Bancrofti*. A, Adult male × 7.5; B, Embryo from hydrocele fluid × 300. (After Lothrop and Pratt.)**

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

**Fig. 3548.—Metamorphosis of *Filaria Bancrofti* in Thromb of Mosquito. A, Just ingested; B, posterior end; C, five days old; D, ten days old; E, sixteen days old. (After T. L. Bancroft, except A after Manson.)**
more slender than before, 18-20 μ in diameter. These larvae show an alimentary canal with esophagus well differentiated and rudiments of the reproductive apparatus. While some remain in muscles even up to the fifteenth day, the most are gone. By even the twentieth day larvae have penetrated through the skin, and later, in the adult insect, may be found anywhere; thus the variable position of lesions of elephantiasis are explained. In *Anoploderma* James finds that the transformation requires only from twelve to fourteen days, and the activity of the developing embryo is not that of a worm. According to Bancroft the broad inactive form measures 71-53 μ long and the slender active form 151-132 μ long and 2.6 μ broad; in the latter stage the esophagus is two-fifths and the tail one-third of the entire length.

It is suggested that simultaneously the mosquito might serve as a carrier of the embryonic filariform 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 blood, the embryos seems to pass through the thoracic wall of the insect and wander 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 evidence that the larvae have attached themselves to the thoracic muscles, and those found after metamorphosis, and changes in such as are retrogressive.

According to one view the worm escapes by boring its way out at the time the mosquito is depositing its eggs in 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 are conveyed to the human subject. He also says the embryos never escape naturlaly 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 larvae 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 Bashir* in India, probably also *Anopheles wootoni*; 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 by Salisbury in 1808, who found the ova in the urine. Some years later (1886) Guiteau described *Filaria Bancrofti* in the South, reporting four cases from Key West and one from Charleston, S. C. Only a little later De Saus pured a clinical history of twenty-two cases, also from Charleston. Since then many cases have been described in the 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 the cases of Boston importation 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 the blood. 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 in the adult, as well as in the males, rarely again gain the circulation by way of the thoracic duct. The embryonic blood filariae were first observed by Demarquay, of Paris, in a man from Havana, who was suffering from elephantitis. The name *F. sausii* has been given to this filaria or *F. bancrofti* in India, and in 1886, was found in different species, 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 species independence. Such embryos have been reported from urine, tears (?), and secretion of the Meibomian glands as well as from the blood in cases of chylocele and elephantiasis, and also in apparently healthy individuals. In the Barbadoes there are thirteen of the patients examined by Manson who 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 filaria may be reversed also, the explanation of von Linstow appears more probable, namely, that the torsus of the capillaries is reduced during sleep; and that the embryo, which after penetrating the capillary walls enters them during the day, finds 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.

In the course of the disease is evidence of the parasitism of the adult in some part of the lymph system. The duration of life of both adult and larve 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 leukocytes with an increase of eosinophiles is noted in early stages, to disappear later. The adults occlude lymphatics and produce lymph stasis with resulting dilatation of the lymphatic
phatics. 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 forty to fifty millions of embryos in the blood of a single man, and yet the individual suffered no apparent effects. It must be said, however, that the results of the parasite are brought about gradually; they are primarily a varicosed condition of the lymphatics, giving rise to various conditions, such as chyluria, varicose inguinal glands, lymph scrotum, chylode, lymphatic fistula, 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 (fuchsian, 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 male, and only twelve per cent. of the female, of the population is drugged, and the adults live in 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 in this country and abroad.

*Filaria magathaei* R. Blanchard 1895.—(Syn.: *F. bentrofti* Cobbold 1893 *F. magathaei* R. Blanchard 1893 *F. magathaei* R. Cobbold 1878.)

Body slender, elastic, resistant; cuticle heavy, cross striped. Female, 155 mm. long, 0.30 mm. broad at head, 298 mm. broad at widest part of body. 0.7 mm. long, 0.46 mm. broad, and 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, papillae of nulliborary form (Fig. 311), smaller (1) spicule 0.39 mm. long, longer unknown. Eggs 98 by 14 μ; embryos 0.30-0.35 mm. long and 5 μ broad with transversely striped cuticle.

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

The life history is unknown.

*F. persooni* Manson 1891.—(Syn.: *F. sanguinis hominis* sp. Mans.)

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 nune, exceedingly delicate filiform spine set on a papilla; this structure may be prolonged and retracted rapidly. The embryos not only multiply, but also travel about very rapidly. It is not numerous, but may be found in company with *F. nocturna* and *F. ducuna*.

The adult was found by Daniels in a native of British Guiana, in whose blood both blunt- and sharp-tailed (*F. dioculata*) embryos. It must be noted that 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-thousand to one-half are infected, and most such show the earlier symptoms of this disease in nearly all cases in which *F. persooni* 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. oesovisi* Manson 1891.—Male, 45 mm. long; 0.06 mm. broad; female, 70-80 mm. long by 0.12 mm. broad. Embryos are found in blood, without sheath, sharp-tailed, 0.173-0.230 mm. long by 4.5-5 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 of people of all which is regarded here as belonging to this species, and the other, which was viewed by Manson as *F. persooni*, 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 Linsow regards them all as developmental phases of one species, I cannot concur in this conclusion, so widely at variance with their differences in structure, habits, and distribution. They may be briefly noted as follows:

*Filaria ducuna* 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. ducuna* were found in one of the races, Manson regarded it as very likely that *F. ducuna* is the larval form of that species.

*Filaria demorpozi* 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 at Martinique. They have also been reported very recently from other localities in the West Indies. They resemble the embryos of *F. bentrofti* 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.

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

*Filaria romanorum-orientalis* Sacchi 1895 is a species observed in the blood of a Romanian 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 Triechynellidae. Body extremely elongated with (two distinct regions, the longer anterior very slender and the shorter posterior more or less enlarged. Osophagus very long, anus terminal. Male sometimes without a spicule, more often with a single simple one which possesses a sheath. Female with sim-
Of the half-dozen genera only two are important here, but they include two of the commonest and the most feared of human parasites.

Triechoecephalus Geeze 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. Parasite in the large intestine and cecum of mammals.

Triechoecephalus trichiurus (L. 1771).—(Syn.: Ascaris trichiura L. 1771; Triechoecephalus Geeze 1782; T. hominis Schrank 1788; T. dipther Rud. 1801; Mastipogas 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 sinus 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 esophagus, 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 esophagus 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 Grassia.

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 Gottingen 40.1 per cent., at Basel 33.7 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.—Triechoecephalus trichiurus inhabits the human cecum 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 pathogénic 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, since Askamazy has shown the occurrence of hemoglobin 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 pelletine have been used with only moderate success. The larval form, known as the _male_ trichina, is found encysted in muscular tissue. 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 faces and do not reach the muscles.

History.—Encysted trichinae were first noted by Peacock in London as early as 1828, but it was 1835 before their character as encapsulated citozoa was recognized by Paget and the parasite described by Richard Owen. The presence of encysted trichinae 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 Richenmeister, together with the observations of Zenker on a mallard that had died of trichina, 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 harm-

less 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 larvae are set free in the stomach and pass into the small intestine. They attain sexual maturity by 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, that the larva is carried ultimately into striated muscle tissue. At birth they measure 0.09-0.11 mm. in length by 5-6 /x 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 striated muscle, 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 about seven years. It 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 encysted. From eighteen to 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 around 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 trichinae can also be the result, and is likewise held to be a pathogenic process. Such larvae as rarely occur in connective tissue are without the characteristic cyst, but appear to be smothered in a mass of proliferating connective tissue.

![Fig. 3533. Fully Developed Muscle Trichina with Accessory Canal and Genital Primordium, Removed from Cyst. Magnified. (After Leuckart.)](image)

**Fig. 3533.** Fully Developed Muscle Trichina with Accessory Canal and Genital Primordium, Removed from Cyst. Magnified. (After Leuckart.)

![Fig. 3554. Encapsulated trichina. (After Leuckart.)](image)

**Fig. 3554.** Encapsulated trichina. (After Leuckart.)

![Fig. 3555. Muscle Trichina Fifteen Days After Infection. X 165. (After Leuckart.)](image)

**Fig. 3555.** Muscle Trichina Fifteen Days After Infection. X 165. (After Leuckart.)
While it has been determined experimentally that a considerable number of hosts furnish conditions favorable for the development of the trichine, the normal host is no doubt the rat, and evidence has been adduced to prove the introduction of this parasite into Europe from 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: 1860-1880-2,841 cases, 318 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 the 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 $8,000,000, while for the city of Berlin alone the cost is $800,000. 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 19 cases and 3 deaths alleged to have been due to American pork during 1881-88, 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.

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 Leuwardt with others has remarked that greater success would follow more rigid search. In the United States Williams has subjected into his third and five cadavers to a careful microscopic 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:

The infection of rats varies so widely in different localities that little dependence can be placed on figures herefore 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 trichine 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 may be made readily by the discovery of embryos in bits of muscle removed from the patient by scalpel or special hook.

The occurrence of other nematodes of somewhat similar size and appearance, the so-called false trichine, 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 esophagus, 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 trichine. 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 is now known that the bacular cyst is a protective stage, such methods of curing ham do not afford a guarantee for the death of trichine 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, this is expensive and does not afford absolute protection. Furthermore, unless the number of trichine 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. A method of killing (by boiling) eggs in the raw or boiled state, without a single analytical rib. 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 bloated, with a few (three to six, or even eight or nine) eggs in each lobe; eggs oval, 63-70 by 41-38 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-mortem in Egypt. It occurred in the stomach and duodenum of man and the camel. The infection was regularly light, and Looss doubted its pathogenic character. He based his opinion on account of this as well as its small size and unarmed buccal suckers. Later Ibni reported a record made by Ogata of the discovery of as many as two hundred small nematodes in the alimentary tract of digesting fluid taken from the stomach of a woman who died in Japan during the "Miura plague" of 1889. These parasites were identical with Looss’s species except that 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.

In view of their occurrence in such widely separated re-
Nematoda.  
Nematoda.

gious, 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.

Dickophyra renula (Goeze 1782.) — (Syn.: Ascaris ovis et variis Schrank 1778; A. visceralis et renula Geeluiu 1789; Strongylus gigas Rud. 1802; Entostomela gigan Diesing 1851; Strongylus renula Moq.-Tund. 1860; Eu. visceralis Baill. 1885.)

Generally blood red, slightly tapering at both ends, especially the anterior; mouth triangular, bordered by six small papillae. Male, 9-12 mm. long; Caudal extremity obtuse, encircled by membranous pouch without rib lines, but with papillae on margin. One slender spine, 5-6 mm. long. Female, 20 cm. long; 5-12 mm. broad; tail obtuse and slightly curved; anus terminal; female sexual opening, 50-70 mm. from anterior end; eggs oval, thick-shelled, brown, 64-68 μ, by 40-43 μ.

This is the giant of all the nematodes, and is a kidney parasite encountered in man, dog, cattle, horses, goat, 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 embryo 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 ascribed to the intestinal 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 Frölich 1789.—Anterior end curved dorsal; 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 (uneinate); 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 most 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 uncinariasis should be adopted as the correct designation of the disease which is known also as brickmakers' and miners' anemia, Egyptian cholera, tunnel disease, etc. Its chief symptoms are anemia with the circulatory disturbances accompanying the pernicious type, colicky pains in the abdomen, weakness, alternating constipation and diarrhea with brownish or bloody stools, nausea, and edema. Positive diagnosis is made by the discovery of the parasites and eggs in the feces. 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 esophagus 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 grains of thymol at 8 A.M., repeated at 10 A.M., and castor oil or magnesia at noon. Diet of milk and soup. As soon as the fever is destroyed, a re-examination of the feces 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 microscopic examination of the feces and treatment of all infected individuals are necessary preliminaries to its eradication. The construction of water-tight latrines in tunnels, brickyards, and other corporations 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 public 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,
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 larvae coming on to the skin, so that the presence of such larvae 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 scale which showed it to be the cause of the severe miners' anaemia, which was associated with the construction of the Saint Gothard tunnel. It is only within the very recent year 1902, that Siles 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 and the Philippines, echinococcosis has been for centuries the most important and dangerous general disease, involving twenty-three per cent. of the population of the region. From the discovery by 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 anaemia.

*Uncinia duodenalis* (Dub. 1848) Railliet 1883. — *Syn.: Agchylostoma duodenale* Dub. 1848; *Strongylus quadridentatus* v. Sieb. 1851; *Anchylostoma duodenale*, Dub. 1850; *Dochmius duodenale* Molin 1860; *Nematoidea duodenale* Cobbold 1861; *Str. duodenalis* Schn. 1866; *Dochmius duodenalis* Linc. 1876; *Anchylostoma and Ancylostoma duodenal.*

Body of the buccal cavity with two pairs of uncinate ventral teeth, and one pair of dorsal teeth, directed forward; dorsal rib not projecting into capsule. Female, 16-18 mm. long by 0.5-0.6 mm. wide; larva at or posterior of 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 trilobulate, and with prominent lateral lobes united by a ventral lobe; spicles 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 dorsal at the anterior end on account of the shortness of the dorsal wall of the buccal capsule, so that the orifice actually points dorsal.

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 faces 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 the 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 molting once it enters upon a resting stage within the cast-off skin of the second molt. In America, the infective 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 larvae on moist salads and other vegetables, eaten uncooked, may well be a subsidiary means.

Recently Looss has brought forward the idea that these larvae may enter the human body by way of the skin, which stands in perfect agreement with his earlier observation of infection of animals with larvae in standing water which did not settle down but were discharged per anum unchanged; yet part of them bored into the mucosa of the larynx and esophagus, 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. 5561), a fourth with provisional buccal capsule (Fig. 5562), and a fifth into which this organ correspondingly develops. 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 lamb about to be amputated and the subsequent discovery of many larvae, 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 worm are not sent to work 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 esophagus, 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. 5561), a fourth with provisional buccal capsule (Fig. 5562), and a fifth into which this organ correspondingly develops. From four to six weeks from the time of infection are required for the parasites to mature.

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branch bipartite to tip (Fig. 3563). Species otherwise similar to *U. duodenalis*. This form has only just been differentiated by Stiles from the long-known European *U. duodenalis*, from which in fact it differs radically. It has been obtained from cases of ascariasis in man in Texas, Virginia, Florida, Porto Rico, and Cuba, and its wide occurrence goes to show that the parasite, though not recognized hitherto, is endemic in the Southern States of the United States, and is most abundant in sandy areas. Guite-ras has also an unpublished case from Brazil.

Ascaris americana von Linstow 1862.—Cuticula heavy, lamellated, forming a projecting ring about the head, within which a pair of equilateral lips bear four papillae in the submedian line and two conical teeth near the mouth opening. Oesophagus one-fifth the entire length; lateral lines strongly developed. Male, 14.32 mm. long by 0.71 mm. broad; female, 20.56 mm. long by 0.82 mm. broad, tapering posteriad, with central longitudinal rows of small conical papillae: spicules two unlike; lateral to the cloacal orifice two pairs of long stalked papillae, in front one pair, behind two pairs, on the tail three pairs more. Female, 27 mm. long, 1.14 mm. broad, vulva at one-sixth the length from the anterior end; eggs heavy shelled, 37 by 36 µ.

The single account of this species by O. von Linstow is based on specimens, two males and nine females, in the collection of the museum at St. Petersburg. They are said to have been taken from the alimentary canal of man in the Caucasus. Further details are not given.

Family of the Ascaridae.—Body relatively thick; mouth surrounded by three lips, one of which is dorsal, the others ventrolateral; oesophagus long, muscular, inflated at the end and often accompanied by an esophageal bulb; male with one or two spicules; female with double ovary, oviparous; development direct. All are intestinal parasites.

Ascaris L. 1758.—Polymyaria, with very prominent lips; males with two equal spicules and many preanal and postanal papillae; vulva in advance of centre of body. More than two hundred species are recorded; three have been reported from man.

Ascaris lumbricoides L. 1758.—Body reddish or grayish-yellow when living; spine-shaped; lips (Fig. 3566) almost similar, approximately semicircular, with fine teeth on the edges, the dorsal possesses two papillae, and each of the ventral ones only a single papilla. Male, 15-17 or even 25 cm. long and 3 mm. thick, with the posterior end curved toward the ventral face; spicules two short, 2 mm. long; papillae fifty-five to sixty preanal and seven pairs postanal. The female, 20-25 or even 40 cm. long and 5-5.5 mm. thick, with straight conical posterior end. The female sexual opening at the limit of the anterior third of the body, and situated in a ring-shaped depression. Fertilized eggs (Fig. 3567) elliptical, shell with transparent, mammillated covering, 50-75 µ long by 40-58 µ wide, laid before cleavage begins. Unfertilized eggs, irregular, with scanty albumin covering, coarser granules, and thinner shell, measuring 81 by 43 µ.

This species is one of the most abundant and widely distributed of human parasites. It is distributed over the entire world, and though more abundant in the warmer regions, is recorded from Iceland and Greenland. It is also more common in the country than in cities, which may be due to the presence of the same species in the pig and sheep. This parasite was well known to the ancients, both the Greeks and the Romans, although the *ascaris* of Greek authors is the form now known as *Ocyurus*.

Life History.—The development of the eggs does not begin until long after they have been expelled from the human intestine, and is dependent upon both moisture and warmth. Under mean temperature the embryo is completed in from thirty to forty days, and then lies in a spiral within a thin shell, which it does not seem to leave so long as the egg remains free, the first moult occurs when it reaches the mouth. The embryo may live long within the shell, even up to five years. The further development was believed by Loeckart to require the intervention of another host in which a larval stage is passed, but Dovazene was successful in hatching the embryos in the intestine of the rat, and believes that the intervention of a second host is unnecessary. Subsequent experiments by various authors have strongly confirmed this view by raising experimentally adults in the human alimentary canal two months after the ingestion of eggs containing embryos. Accordingly the eggs are probably introduced into the human system with the embryo within or by chance or by means of the drinking-water. The embryo is then set at liberty in the alimentary canal, and further development is merely growth. Of course the infection may be brought about by the means of contaminated vegetables, especially salads, which have been imperfectly cleaned.

Pathology.—It is already unimportant that the worms are most frequently found in children of medium growth, but this is due to the ease of infection rather than to conditions for development, since the worm has been obtained from persons of all ages. Ordinarily one finds only a few specimens at once, but in some cases from five hundred to one thousand have been obtained from a single individual. It is noteworthy that haemoglobin has been detected in the alimentary canal of the
Nematoda*

B. mm. single handling mystax santonin the favorable santonin tinctly of they are blood vomited. Thus have been shown, causing the fatal intestinal, etc. Ascaris, centigrams have been brought forward in which the worms have been found in abscesses of the liver. Recently a number of unimpeachable cases have been brought forward in which the worms have been found, having pierced abscesses of the wall is also known, and in some cases even, in which adhesion of the intestinal to the abdominal wall was present, the worm emerged from the body through an abscess at this point. In fever the Ascaris worms spontaneously descend the intestine. It is evident that these wanderings are associated with great danger to the host. The presence also of a few individuals in the intestine gives rise at times to marked nervous disturbances, hysteria, epilptic attacks, congestion of the brain, aphonia, etc., which are more easily explained on the basis of a poison excreted by the worms. In fact, recent investigators have been able to obtain such a toxic substance from the body of this species, and students in the laboratory handling specimens of A. meguroplato from the horse have been distinctly affected by poisonous emanations. The symptoms disappear with the removal of the worm. Unluckily, however, is inclined to attribute the troubles in large part to the use of santonin for the expulsion of the worms, as this substance has an unfavorable effect upon the human organism. Gulart has called attention to the important fact that the parasites by their movements produce lesions of the wall so as to afford a point of attack for intestinal fevers, and thus become a source of great danger for the host. Kotted masses of this parasite have also been the cause of fatal intestinal obstruction. Treatment - In general opinion, santonin is the specific against Ascaris, and no one of the many other substances tried has achieved the same results. Moniez advises the use of centigrams equal to the number of years in a child's age, and for an adult 20-25 cgm. The drug kills the parasites, and the adjuvant simultaneous to the same time of a purgative is advantageous in bringing about their immediate expulsion. Careful watch should be kept for the violent symptoms which sometimes accompany the use of santonin and means taken at once to counteract them. Ascaris canis Blanchard. - (Syn.): *Lumbricus canis* Werner 1782; *A. teres* Goze 1782; *A. cati* and *canicular* Schrank 1788; *A. canis* and *felis* Gmelin 1789; *A. triosplata* and *felis* Bruguieres 1791; *A. Wernieri* Rud. 1793; *Phasmodon* Zeder 1800; *H. marginata* and *H. mylata* Rud. 1892; *H. alata* Bellingham 1890.

Anterior end ordinarily curved and provided with two wing like membranes which extend one along each side (Fig. 3568), lips almost equal, three to six-cornered. Male 30-90 mm. long, broad, with twenty-one preanal and five postanal papillae. Female, 120-200 mm. long, vulva in the anterior fourth of the body, eggs almost spherical with thin shell, 0.065-0.072 mm. in diameter.

An abundant parasite in the small intestine of cats and dogs and also reported from various allied wild species. It has been found several times in man in England, Germany, Denmark, and the United States. Grassi doubts the accuracy of these determinations since experimental infection was not successful.

Development is direct and in general like that of the preceding species. The thin shell is highly imperious so that development continues in alcohol, turpentine, etc. It is probable that the embryo does not desert the shell until taken into the stomach of the host.

*Oxyurus* Rudolphi 1865 - Three lips poorly developed or wanting; esophagus long and provided with a distinct bulb. Male with only one spicule and two pairs of papillae. Female with greatly elongated pointed posterior end, two ovariies and vulva in anterior part of the body.

*Oxyurus vermicularis* Breunac 1819 - (Syn.): *Ascaris vermicularis* L. 1758; *Procaris* vermicularis Leufrart 1876. - Known only from a single immature female, which was vomited by a child in North Greenland in 1865. The specimen was 43 mm. long and 1 mm. broad, and is regarded by some authors not as a normal parasite, but as one accidentally digested with the viscera of some rodent animal. According to Leufrart it is very near *A. tetragonos* of the bears.

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in the canal. In fact, however, the female at the time of oviposition lives in the lower part of the rectum and even attains the vicinity of the anus, although the earlier portion of the adult life history is passed in the small intestine, where the worms acquire sexual maturity and copulation. In mature specimens, the proboscis undergoes transformation to the second embryonic stage while still within the egg shell, and now awaits ingestion by a new host. The primary infection is by drinking-water or contaminated fruit or vegetables, which are eaten in uncooked, but self-infection and transference to other individuals are brought about by scratching and rubbing with the fingers to allay the intense itching caused by the daily migration of the females out from the anus on to the perineum and the surrounding parts. Pericyst in the distribution of Oxyuris eggs the flies play a part such as Grassi has demonstrated for Trichocephalus and eggs of Taenia. The direct development is very rapid, as Leuckart obtained experimentally Oxyurides 6-7 mm. long within fourteen days after ingestion of the eggs; Grassi and others have confirmed this by further experiments.

Pathology.—The females are far more numerous than the males, and by their migrations determine unbearable pruritus, which recurs periodically on retiring. In a number of cases among young girls, the vagina has been penetrated by the embryos and cases have been noted under Ascaris. Recent investigations in Egypt have demonstrated the responsibility of this parasite for nodules on the rectal wall, previously attributed to Schistosoma, which contains eggs of Oxyuris vulvolaris in a calculus. Oxyuris has also been recorded in tuberculous nodules in the cæcum of a female, and Vuillemin has recently discovered them in a tumor near the anus of a boy. The latter case shows definitely the wandering of the worms through the body, and in solid tissue. This habit exhibits a new and evidently dangerous feature in the parasitism of this species through the occurrence of the parasites and the introduction into them of bacteria from the rectum.

Treatment.—It is difficult to remove these worms entirely. Vermifuges and purgatives with cinchona, etc., are successful to a degree; but the case of auto-infection is an obstacle to a complete cure. Local application of mercurial ointment will alleviate the pruritus, and manual extraction, if prolonged, will reduce their numbers rapidly. But in any event treatment is prolonged.

The sub-class of the Gordiacea includes forms familiarly known as "hair snakes" or "hair worms." They are greatly elongated, slender worms, somewhat flaria-like in external appearance, but of cylindrical or oval in outline, and have a well-defined structure. Lateral fields are wanting, and the body musculature is of a different histological type from that of the Eunematoda. The mouth is everted and the alimentary canal persists in the adult only as a functionless vestigial strand. In both sexes the reproductive organs open to the exterior with the alimentary canal at a terminal, or subterminal cæcum. The reproductive system is constructed on a different plan, and the lateral canal system is wanting. The male has no spicules, but the posterior end of the body is forked and functions as grasping organ.

The adult lives free in ponds, swamps, and other bodies of water, and the eggs are deposited on the stems of water plants. The larvae possess a proboscis armed with hooks and bore into the body cavity of aquatic insects larva, or rarely mollusks, where they encyst. According to Villot the second stage is passed in the intestine and body cavity of fishes. More commonly apparently the worms develop in the body cavity of insects, from which they emerge into the water for the adult free existence.

Several species have been reported from the human alimentary canal. They are pseudoparasites, having been swallowed, according to one view, in the adult condition with drinking-water; but their occurrence in fruit, especially apples, makes this even a more likely source of infection. Lockwood noted in 1876 the frequent presence, in fruit, of Mermis nigra in the United States. The group Parona has recently listed eleven cases, the first as early as 1688; of these Kirkland's (Ohio) is the only one from the United States. Two other unpublished cases have recently been reported. They have communicated to me from Michigan and Marylnd. It will be of no particular value to enter here upon a detailed description of the species found.

The Gordiacea are, however, emphasized by Cobb as important for the medical practitioner, since they have been widely spread over the earth and have possessed and possessed and possessed the stomach of the man under conditions; this has not been actually recorded so far as I find. But of Gordiacea they have been recorded in a number of species, many with parasites. The group Parona has recently listed eleven cases, the first as early as 1688; of these Kirkland's (Ohio) is the only one from the United States. Two other unpublished cases have recently been reported. They have communicated to me from Michigan and Maryland. It will be of no particular value to enter upon a detailed description of the species found.

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Fig. 375.—Gigantorhynchus gigas opened to show Internal Anatomy, by Lockwood. (Lit. 285.)—Gigantorhynchus gigas (gigant) (Syn.: Tenia briviulae Pallas 1781; Echinorhynchus gigas Goode 1782.)—Body milk white, sometimes slightly tinted, with transverse irregular ridges. Posterior end somewhat smaller; proboscis spherical, armed with five or six rows of hooks. The proboscis can be retracted in the body cavity, region, which is much narrower than the remainder of the body. Male, 30-90 mm. long by 3-5 mm. broad, with bell-shaped conical pouch. Female, 250-350 mm. long by 4-9 mm. broad; tail blunt; eggs almost cylindrical, 0.085-0.11 mm. long with three embryonic envelopes.

The adult worm is found in the small intestine of the pig, ordinarily fixed to the wall by the proboscis, and is widely distributed. Structure.—The elongated body (Fig. 3370) is largest near the head and tapers gradually toward the posterior end. At the anterior end a sharp constriction separates
Echinorhynchus, sp. Moniez 1896.—Künstler and Pitres found certain peculiar bodies in the pleural cavity of a patient who had suffered two years from pleurisy, but without fever. They interpreted these structures as coccidia, but Moniez holds with greater probability to the likeness to cestodes, Echinorhynchus. The case is entirely isolated under either explanation.

Henry B. Ward.

NEOPLASMS. See Tumours.

NEXPHRETOMY; NEPHROTOMY. See Kidneys, etc.

NERVES, GENERAL PHYSIOLOGY OF.—HISTOLOGICAL AND GENERAL.—Nerves consist essentially of the long, slender processes of nerve cells. They are hence composed of protoplasm, and they possess the general chemical and physical properties of this substance; but they differ physiologically from other forms of protoplasm, in that they possess to a high degree the properties of conductivity and excitability, while the properties of growth, metabolism, respiration, and contractility are feebly developed or altogether absent. There is in these respects a marked physiological difference even between the nerve cells of the embryo and the cells of the adult which they supply. Many of the reactions of the cells to external conditions are the opposite to the reactions of the nerve. The cell generates nerve impulses; it possesses spontaneity or automaticity, absent in the fibre; it is closely dependent on a supply of oxygen, while the nerve is almost independent; it has an active metabolism, which the nerve lacks almost entirely; it requires, while the nerve requires little or not at all; it or some of its dendritic processes may be contractile, the nerve has lost this property altogether. The peculiar physiology of the nervous tissue, which includes nerve cells, differs therefore in many respects from that of the nerves proper, which we shall consider here. In short, the nerve cells possess pre-eminently the property of automatisms or spontaneity; the nerve fibre, the property of conduction.
This physiological differentiation of the conducting protoplasm of the nerve is accompanied, as might be expected, by an histological differentiation. The protoplasm of the nerve fibre, called the axis cylinder, or axon, differs in physical appearance from that of the rest of the nerve cell body from which it is derived, in that the fibre is surrounded by the nucleus until, as if composed of distinct fibrils, and is surrounded by a fatty sheath. These fibrils can be more easily seen in invertebrates than in vertebrate nerves, and particularly in the leeches, where they have been traced by Apatby.1 From one nerve cell into another a small portion of the axis cylinder connects. Some fibres even so far as to maintain that these fibrils are the true conducting portions of the fibre, but of this there is no physiological evidence. Besides this peculiar fibrillar structure of the axis cylinder, nerves are as a rule easily differentiated from other tissues by the naked eye by their white, glistening, fatty sheaths. Nearly all nerve fibres which take their origin in the brain and spinal cord, and many having origin elsewhere, are surrounded by such a sheath, which is called the medulla, and some others are nourished. Axon fibres differ from invertebrates and those of the sympathetic system of vertebrates, on the other hand, often lack these sheaths, and are called non-medullated nerves. The function of this medullated sheath is not definitely ascertained, but it is suggested that it has a spreading or of the impulse from one fibre to another. It appears to influence the physiological behavior of the nerve, for medullated nerves are generally much more easily and of greater rapidity, and distribution to an exposure to a constant electrical current. A momentary exposure of a non-medullated nerve to a constant electrical current may block conduction in the region of the anode or positive electrode for several minutes, or even hours after sublimation. Medullated fibres differ from other protoplasm also in the quickness with which they stain blue when exposed to a solution of methyl blue. It is thus possible to stain them before the other tissues are colored, and an important method for tracing the course of the distribution of nerves has been founded on this peculiarity.

The chemical composition of the axis-cylinder process is not definitely known. Other portions of grey nervous matter which resemble consist largely of colloidal substances of protein nature, and differ from most tissues in the unusually large amounts of lecithin and cholesterin present. Nothing can be said positively regarding the inorganic salts present in the axis-cylinder process. Ranke believed its reaction to be slightly acid, but most observers have found the cut surface of the nerve alkaline to litmus; it is possible that like other protoplasm it is neutral to phenolphthalein. The medulla consists chiefly of cerebrin, lecithin, cephalin, cholesterin, and neutral fatty acids. The chemical constitution of the medulla is probably monomethyl cholin lecithin. The constitution of cerebrin is unknown, but in the brain of the sheep it contains the sugar galactose, two or four molecules of water, and sometimes also two or four molecules of phosphoric acid, or instead of this, sugar, amino-acid, possibly to a hexonic alcohol or to glycine. The cerebrins obtained from the brains of different animals differ chemically. The high content of all nerve tissues in lecithin and cholesterin is probably of physiological importance.
Parasites.
The paraplegiform affection due to the ataxia of tabes dorsalis may give place to a true paraplegia by an extension of the degenerative process to the anterior cornua, producing muscular atrophy, or, in the form combined with sclerosis, by involving the pyramidal tracts. It may imitate spinal paraplegia and hysterical paraplegia.

**Spastic Paraplegia** results, as we have seen, from the symmetrical involvement of the pyramidal tracts in any part of their course, and is usually secondary to a transverse myelitis, or to a transverse lesion of the pyramidal tracts in their intramedullary portion, or partial ataxia. In both, arrested development of the cortical motor areas in both hemispheres. It is sometimes termed double hemiplegia. It may affect chiefly the arms, or the legs, and has the usual characteristics, namely, spastic movements, exaggeration of reflexes, and absence of sensory and trophic changes. Primary sclerosis of the pyramidal tracts in the cord is a rare condition, if it occurs at all.

Intracranial tumors, by pressure upon the crura and pyramidal tracts in the pons and medulla, or in the central gray matter of the medulla, produce paraplegiform symptoms, in some cases being ataxic rather than paravit, or a combination of both.

**Paraplegia from Multiple Neuritis** is characterized by both motor and sensory impairment involving all the extremities, and ascending the members from periphery to trunk, also by pain, hypesthesia, tenderness of the nerve trunks to pressure, trophic changes in the muscles, the reaction of degeneration, edema of the extremities, and vaso-motor disturbances (blush or pallor), and the absence of a constriction band. It is most common in those addicted to alcohol, but is also a manifestation of certain endemic diseases, such as beriberi or kakki.

**Pseudo-hypertrophic Paralysis** produces a form of paraplegia somewhat similar to poliomyelitis anterior, and is considered by some to be a form of that affection, by others to be a connective-tissue disease of the muscles. The increase in size of the muscles (usually the calves), serve to distinguish it from ordinary poliomyelitis anterior.

There are several forms of paraplegia usually classified under functional disorders of the nervous system, namely, hysterical paraplegia, paraplegia depending upon idea, reflex paraplegia, afferent paraplegia, alcoholic paraplegia, and toxic paraplegia.

**Hysterical Paraplegia** is a less frequent form of hysterical paralysis than that of hemiplegia or monoplegia distribution. It is less apt to be confounded with paraplegia from lesions of the spinal cord, while hemiplegia than paraplegia from the reason that hysterical paraplegia resembles in its symptoms a lesion of cerebral motor tracts in the brain and cord, rather than one in the remaining portion of the motor tract in the cord and peripheral nerves. The reaction of degeneration, edema of the extremities and vaso-motor paralysis may be present, but it is that form which is dependent upon disease. The volume of the muscles may be reduced in such cases, and may give a feeble reaction to electrical excitation; but, what is of the utmost importance, paralytic extirpation is preserved, and the converse is true.

The skin and muscles may be cold, livid, and flabby, resembling paralysis from peripheral or central nervous disease, and contractures may form as in degeneration of the pyramidal tracts, though in many cases the muscles and skin appear normal, except that voluntary control is lost. The tendon reflexes are rarely lost; usually they are increased, sometimes excessively so. The bladder and rectum are not usually affected, though voluntary control over these organs may be lost. Thus, paraplegia from transverse myelitis of the lumbar enlargement would not be confounded with hysterical paraplegia on account of the absence in the latter of trophic and electrical changes in the muscles and nerves, beisores, and atrophic changes in the bladder; but the latter might closely resemble paraplegia from transverse myelitis if its development were absent. The presence of a constriction band at the level of the segment involved, and the sensory, motor, or reflex disturbances in this zone would exclude hysterical paraplegia. Hysterical paralysis of all the extremities might simulate cervical paraplegia of myelitic origin, but would be differentiated from it by the presence of trophic changes in the muscles of the upper extremities, and by the vaso-motor and visceral symptoms which accompany organic lesions of this region. By the onset and course of the two classes of disease are usually sufficient to distinguish one from the other. The irritable stage of most acute or subacute organic diseases of the cord, in which pain, hyperesthesia, and slight motor irritability precede and accompany the paralytic and anaesthetic period, is usually present in hysterical paraplegia. In the latter, sudden development of the paraplegia, and sudden variations in its distribution and intensity, often serve to indicate it. Anesthesia and analgesia may have a distribution inconsistent with the lesions producing paraplegia of structural origin.

It must not be forgotten that hysteria may accompany organic lesions, and should not, therefore, be taken as proof of the hysterical nature of the paralysis, unless organic lesions can be excluded.

**Paraplegia Dependent upon Idea** is a form described by Dr. J. Russell Reynolds. Though closely allied to hysterical paralysis, it may be independent of it. If a part of the body is thought of, it may be felt or, if not, it may be imagined that it is. It is not infrequently associated with functional debility, anxiety, and a morbid imagination. "Many cases of paraplegia following railroad accidents," says Reynolds, "may be classed under this head; the attention of the victim is directed towards that limb which is most useless, and frequently, without a voluntary effort, the imagined limb is moved, either by the direction of friends, inquiries of his physician, the talk of his attorney, and the sober face of the company's physician." Pain, distributed in a manner inconsistent with the anatomical relations, on the supposition of an organic lesion in the part, which, however, is sometimes relaxed in a remarkable way when the patient's attention is directed elsewhere; and paralysis, which is rarely complete, and almost identical with a voluntary attempt not to move the parts, or to move them with care, as in simulation, are the chief features of the affection. The removal of the morbid idea, i.e., that the patient is paralyzed, or has a severe disease, results in improvement or cure. An award for damages has also frequently proven a valuable therapeutic agent in such cases.

**Reflex Paraplegia**, termed by older writers urinary paraplegia, was shown by Brown-Sequard to follow irritation not only of the genito-urinary tract, but also of the intestines and other viscerum in animals. He attributed it to an anemia of the cord, due to contraction of the blood-vessels considered as a local symptom by him, due to inhibitory action of the sensory irritation. While we must admit the possibility of this form of paraplegia, it should not be forgotten that organic lesions may have been lost sight of, or might be sufficiently slight to be overlooked. The persistence of hysterical paraplegia, as from cutaneous irritation, the removal of which has been followed by recovery, is the only basis on which it should be admitted, and then only in the absence of indications of organic disease.

**Paraplegia on Intermittent Paraplegia** is a curious form of poliomyelitis anterior, which recurs with the periodicity of intermittent fever. Alcoholic paraplegia, when not due to multiple neuritis, is a temporary affair, following an alcoholic debauch.

**Anæmic Paraplegia** follows ischaemia of the cord from pressure on the abdominal aorta, and from pressure or occlusion of the iliac arteries within the pelvis, or ischaemia of muscles; rare conditions.

The indications for treatment, where paraplegia exists, are those adapted to the correction of the various pathological processes concerned in the diseases which we have considered. More than a brief résumé would carry us beyond the proper limits of this work. In the irritable stage of acute meningitic and myelitic processes, rest is the best means of relief. When a less irritable condition of the paraplegia, is due to depressive iatrogenic pressure, is the means of agents supposed to cause vaso-motor contraction, such as ergot and belladonna, and the relief of pain by means of cutaneous irritation (the actual cautery, blis-
PARASITES.—A parasite is an organism which lives, temporarily or permanently, within the body or on the surface of some other living thing upon which it feeds. Evidently, then, not only may there be both phytoperasites and zooperasites, but also that form which is parasitized upon and is known as the host may be equally either plant or animal. Among forms which find in man at some time or in some region a subject for attack, the phytoperasites include the prominent group of bacteria which have received attention elsewhere, and a few fungi of zoological importance, in dermal affections chiefly, which have also been discussed. Here will be given a brief discussion of the animal parasites of man, with especial reference to their biological and etiological relations.

It is important to notice first the wide range in degree of parasitism exhibited and the manner in which the various grades merge into one another, producing a scale of dependence in which almost every stage is represented. Most independent of all are the temporary parasites, like the mosquitoes, flies, or leeches, the individual host only long enough to secure a single meal, and which present clearly the structure and habits of free living organisms. Some leeches suggest most plainly the close relation between the carnivorous and the parasitic habit, since they often devour bodily small aquatic forms, but when favored by opportunity extract the blood of larger animals. More dependent are such forms as the fleas which can change their host and often do so, and yet their structure has been highly modified in the loss of wings and other parts which are generally characteristic of insects, and by the development of powerful leaping and grasping organs. Somewhat further modified in the direction of parasitism are the lice, which, moreover, lack special means for effecting a change of host, and may be included among the list of stationary parasites, i.e., those that remain with a single host constantly, or at least for considerable periods of time.

All of the forms thus far noted are parasitic upon the exterior of the host, and some casually are denominated Epizooites or ectoparasites. All human ectoparasites belong to the group of Arthropoda, and include both mites (cf. Arachnida) and true insects (cf. Insecta). Among the water-living animals, however, soft-bodied forms, such as flat worms (Trematoda) and unicellular animals (Protozoa) occur as Epizooites. With the gradual assumption of an aerial or terrestrial existence on the part of the host, such parasites were necessitated, if they had not already sought more sheltered regions, now at least to abandon the external surface and to colonize internal organs where thin mucous membranes and afforded facilities for extracting nourishment similar to those which existed on the thin outer skin of the aquatic animals. The chonea, pharynx, gills, lungs, alimentary canal, and even the bladder were thus invaded by forms whose kinship to the ectoparasitic species on these lower animals is too plain to fail of recognition.

The Entozoa or endoparasites of man, however, do not even belong to the same branch of the animal kingdom as the forms ectoparasitic upon him; with the single exception of the rare and aberrant Linguatulids, which are usually regarded as highly degenerate arachnids (q.v.), though formerly classed with the Cestoda. The human Entozoa include Protozoa, Trematoda, Cestoda, and Nemathelminths, and many of them are highly modified in adaptation to the parasitic mode of existence, as compared to the related free living forms which, however, are entirely wanting in the second and third groups, these respectively being subdermal and subcutaneous, respectively.

The term helminthology has been used as synonymous with animal parasitology, and yet this is a considerable extension of its original meaning. The Helminthiases or intestinal worms included the pre-eminent parasitic groups, such as Trematoda, Cestoda, and Nematoda, with the Protozoa, Arthropoda, and other parasites of the excretory and respiratory system, but these are not here included. The second groups, namely, the Angiostomes, the Arachnida, the Tremato- da and Cestoda to the Phylum Arthropoda, and the Nematoda to the Nemathelminthiases.

Location.—While the majority of endoparasites inhabit the alimentary canal and its adnexa, there is no organ which is immune to their attack. The following list of human parasites arranged according to the organ inhabited will serve to indicate the extent of the parasitic habit, and will assist in the identification of a given form. The records given apply only to the human host, and parasites are entered under the normal method of their occurrence. The numbers in the following list are not necessarily the number of cases on record, but are the number of cases upon which the various data given are based.

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Stage</th>
<th>Type of parasitism</th>
<th>Normal habitat</th>
<th>Recorded cases</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sphagnum and subdermal tissue</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Entodera Nefriens</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Graphostrama annulata</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Fiaria medmiennis</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Uvulaeopsis densale</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Euchromis spiralis</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Vorticella spiralis</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Cystocerca cetacea</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Echinococcus polyxeniforms</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Brain and membranes.</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Cystocerca canini</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
<tr>
<td>Echinococcus polyxeniforms</td>
<td>Sphagnum species</td>
<td>Larva, adult</td>
<td>Normal, Occasionally</td>
<td>Europe, Africa, North America</td>
</tr>
</tbody>
</table>
EGGS OF HUMAN PARASITES
(MAGNIFIED FIVE HUNDRED DIAMETERS)
<table>
<thead>
<tr>
<th>Parasite</th>
<th>Stageevin U. S. A.</th>
<th>Record in U. S. A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brain and membranes</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Paragonimus Westernmani</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Connective tissue</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Manzoonkephalisis</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Cysticercus cellulose</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Cysticercus aequorhimae</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Edemococcus polymer-</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>phus</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Paenagonimus Westernmani</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Mice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cysticercus cellulose</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Cysticercus aequorhimo-</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>phus</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Heart</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasciola Magalhaesi</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Cysticercus cellulose</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Echinococcus poly-</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>phus</td>
<td>Larva.</td>
<td>Normal</td>
</tr>
<tr>
<td>Blood-vessels</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Schistosoma mansoni-</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Bluma</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Echinococcus polymer-</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>phus</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Strongyulus apri</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Lice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Opisthorchis felineus</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Opisthorchis sinensis</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Opisthorchis noverca</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Distomum lanceolata</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Dicrocoelium lanceatum</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>Adult.</td>
<td>Eratite</td>
</tr>
<tr>
<td>Echinococcus polymer-</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>phus</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Paragonimus Westernmani</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Small intestine</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fasciola hepatica</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Opisthorchis felineus</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Opisthorchis sinensis</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Opisthorchis noverca</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Distomum lanceolata</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Dicrocoelium lanceatum</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Tenia solium</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Tenia saginata</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Tenia africana</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Tenia confusa</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Strongyloides stercolitis</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Trichinella spiralis</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Strongyulus subtilis</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Uncinia duodenalis</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Uncinia americana</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Physaloptera mesnei</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Ascaria lumbricoides</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Ascaria canis</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Ascaria maritima</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Anisakis serpula</td>
<td>Adult.</td>
<td>Normal</td>
</tr>
<tr>
<td>Giganthorchys gigas</td>
<td>Adult.</td>
<td>Oesophageal</td>
</tr>
<tr>
<td>Giganthorchys moniliformis</td>
<td>Adult.</td>
<td>Oesophageal</td>
</tr>
</tbody>
</table>

* Present in the United States of America in some other host, hence easily possible in man, although no record of its occurrence in the human host was found.
* Only in female through infection of vagina from rectum.

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Stage</th>
<th>Type of parasitism</th>
<th>Normal habitat</th>
<th>Recorded in U. S. A.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Large intestine</td>
<td>Adult.</td>
<td>Oesophageal</td>
<td>India</td>
<td>Yes</td>
</tr>
<tr>
<td>Trichoecephalus trichuris</td>
<td>Adult.</td>
<td>Normal</td>
<td>Cosmopolitan</td>
<td>Yes</td>
</tr>
<tr>
<td>Oxyria vermicularis</td>
<td>Female</td>
<td>Normal</td>
<td>Cosmopolitan</td>
<td>Yes</td>
</tr>
<tr>
<td>Kidney</td>
<td>Larva.</td>
<td>Normal</td>
<td>Europe</td>
<td>Yes</td>
</tr>
<tr>
<td>Echinococcus polymorph-</td>
<td>Larva.</td>
<td>Normal</td>
<td>Europe</td>
<td>Yes</td>
</tr>
<tr>
<td>phus</td>
<td>Larva.</td>
<td>Normal</td>
<td>Europe</td>
<td>Yes</td>
</tr>
<tr>
<td>Bladder</td>
<td>Adult.</td>
<td>Oesophageal</td>
<td>India</td>
<td>Yes</td>
</tr>
<tr>
<td>Leptodactyllum pellio</td>
<td>Adult.</td>
<td>Oesophageal</td>
<td>India</td>
<td>No</td>
</tr>
<tr>
<td>Angiulus aceti</td>
<td>Adult.</td>
<td>Oesophageal</td>
<td>India</td>
<td>Yes</td>
</tr>
</tbody>
</table>

**SCUPET—EGGS**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
<th>Size in microns</th>
<th>Plate E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasciola hepatica</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Paragonimus Westernmani</td>
<td>Adult.</td>
<td>Normal</td>
<td>Cosmopolitan</td>
</tr>
<tr>
<td>Strengyulus apri</td>
<td>Few cases</td>
<td>50-100 x 30-72</td>
<td></td>
</tr>
</tbody>
</table>

**SCUPET—EMBRYO**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
<th>Size in microns</th>
<th>Plate E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Paragonimus Westernmani</td>
<td>Adult.</td>
<td>Normal</td>
<td>Cosmopolitan</td>
</tr>
<tr>
<td>Oxyria vermicularis</td>
<td>Few cases</td>
<td>50-100 x 30-72</td>
<td></td>
</tr>
</tbody>
</table>

**URINE—EGGS**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
<th>Size in microns</th>
<th>Plate E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasciola hepatica</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
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</tr>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Oxyria vermicularis</td>
<td>Few cases</td>
<td>50-100 x 30-72</td>
<td></td>
</tr>
</tbody>
</table>

**URINE—EMBRYO**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
<th>Size in microns</th>
<th>Plate E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Paragonimus Westernmani</td>
<td>Adult.</td>
<td>Normal</td>
<td>Cosmopolitan</td>
</tr>
</tbody>
</table>

**FECES—EGGS**

<table>
<thead>
<tr>
<th>Parasite</th>
<th>Frequency</th>
<th>Size in microns</th>
<th>Plate E.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fasciola hepatica</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
<tr>
<td>Fasciola magna</td>
<td>Not observed</td>
<td>145-151 x 88-88</td>
<td></td>
</tr>
</tbody>
</table>

**REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.**
Parasites. Parasites.

**FACES—Eggs.**—Continued.

<table>
<thead>
<tr>
<th></th>
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<th></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>Strongyulus stultus</td>
<td>Several cases</td>
<td>66-80 x 34-41.</td>
<td>7.</td>
</tr>
<tr>
<td>Strongyulus apricus</td>
<td>Several cases</td>
<td>50-100 x 38-72.</td>
<td>20.</td>
</tr>
<tr>
<td>Entamoeba histolytica</td>
<td>Frequent</td>
<td>35-65 x 25-40.</td>
<td>37.</td>
</tr>
<tr>
<td>Physaloptera caninum</td>
<td>Reported once.</td>
<td>57 x 39.</td>
<td>1.</td>
</tr>
<tr>
<td>Ascaris lumbricoides</td>
<td>Common</td>
<td>50-75 x 40-50.</td>
<td>5.</td>
</tr>
<tr>
<td>Oxyuris vermicularis</td>
<td>Common</td>
<td>50 x 16-20.</td>
<td>7.</td>
</tr>
<tr>
<td>Giardia lambia</td>
<td>Few cases.</td>
<td>80-100 x long oval.</td>
<td>19.</td>
</tr>
<tr>
<td>Filaria.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Strongyloides stercoralis</td>
<td>Common</td>
<td>200-400 long.</td>
<td>1.</td>
</tr>
<tr>
<td>Trichinella spiralis</td>
<td>Rare</td>
<td>10-30 x 6.</td>
<td>1.</td>
</tr>
</tbody>
</table>

* Many species possible (see key under Nematoda).  

One may recognize among these parasites those which occur in their normal host but in an unusual location, like the brain cysticerci or a liver fluke in a subcutaneous cyst; there are also many of the species listed which can not be regarded in any way as characteristic of the human host. Such are the accidental parasites which are species of true parasitic habit and can attain normal development in the human host, but ordinarily do not find conditions favorable for their introduction. As an illustration, in many parts of the Circum-Mediterranean region, the common liver fluke of the sheep, which in many regions of the world is extraordinarily abundant. That it can thrive in the human system is demonstrated by the score or more of cases of its occurrence there definitely recorded; but its infrequency is equal evidence of a general immunity on the part of man, lacking in these particular cases, or of special features in its life history which make the infection of the human host difficult. That the latter is the probable explanation may be inferred from the fact that the cercaria larvae, liberated from the intermediate host, excavts on grass, and hence could reach the human alimentary canal only under unusual circumstances. Similar examples may be taken from other groups of parasitic forms, such as the rare occurrence of Strongyulus stultus in the commonest parasites of the pig in Europe, or of Dipylidium caninum, the cosmopolitan tapeworm of both dog and cat, which has been reported only rarely from man.  

Such occasional parasites often occur under abnormal conditions; thus a fish nematode, Ascaris clausa, was discovered once in the hollow tooth of a man. Here the position was probably accidental, but in other cases it is the result of the action of the parasite itself. So the "red spurs," or "jigger" mites of the Central States buy themselves in the skin of man, although such a position is so clearly abnormal that in fact it destroys the chance of further development and costs the parasite its life. A small leech, Laimobdella nobilis, common in the Circum-Mediterranean area, is often drawn into the throat of man and other animals drinking at wayside pools. It usually retains its position, causing serious difficulty, until removed by operative interference; hence it has become an occasional parasite of man rather than, as in the case of most helices, a temporary parasite; or one may regard it as falling in the next following group of accidental parasites. This example shows most clearly the narrow and somewhat artificial limits which separate these groups of parasites from one another. Of the mites also, which have been reported a few times as obtained living from stomach, bladder, and rectum, it is difficult to say whether they are occasional or accidental parasites of man.

There are also rarely forms which commonly occur free living, but which by chance are introduced into some organ in which conditions are such that they can thrive. Thus become thus accidental parasites difficult practically to distinguish from the last, the occasional parasites, and yet presenting somewhat different biological conditions. The recent discovery by Stiles and Frankland, as well as others, of the vinegar eel, Anguilla rostellata, as an apparently successful parasite of the bladder in a female patient illustrates the type under consideration. There is little doubt that this parasite was introduced through the use of vinegar in vaginal douches and effected a successful colonization by virtue of the trace of albumin present in the urine which furnished it with nourishment. Similarly striking is the case of Schehr, who discovered Leptodora pellio in the urine of a female patient in Hungary. This typical accidental parasite was introduced by the patient, no doubt, through the application of mustard poultices, which are commonly employed by peasants in that region. It should be noticed that such accidental parasites are necessarily confined to those groups of animals which have free-living forms, such as Protozoa, Nematoda, and perhaps Insects in the larval condition, while Cestoda and Trematoda, which live only as parasitic forms in some host, would become rather occasional parasites of man should they stray into the human system in some chance manner and find favorable conditions for existence.

Quite distinct from the types just considered are pseudo-parasites, which rank high in clinical importance. Among them one may recognize several very distinct classes. First, those which are accidental parasites, introduced by accident, usually in food or drink, into the human alimentary canal, exciting there abnormal conditions which induce their more or less immediate and formidable expulsion. Thus Botkin found in the vomit of a Russian number of a small nematode which he wrongly believed to be a human parasite. In fact, it lives normally in the onion, and its introduction into the stomach with this food excited the untoward symptoms noted. Similarly Blanchard records a case in which, no doubt, coleopterous larvae were found in the vomit of a child. That such may be the result of introducing a true parasite from some other host is indicated by several cases, like that of Ascaris maritima, which Leuchart described from a single specimen vomited by a child in Greenland, and which this author noted was very similar to A. transfigata of the brown bear. In all probability it was ingested with the viscera of some animal (soap), though it may have been a species which had strayed into this unusual host in order to make its appearance under the circumstances noted.  

Of similar import are the cases of Gordius, the hair snake, which have been reported from man. In the adult condition this is normally a free-living species, but about a dozen specimens have been taken from man after a supposed sojourn of from a few hours to fourteen days. Some of these have been vomited and others passed per anum. This form has often been passed off upon the physician as a true parasite, and in one celebrated case at least as the Gulicina-worm.  

In the same way one may find the explanation for other isolated cases of parasitism, even when the parasite is reported to have been passed from the alimentary canal. Thus Cobbold reported that larvae of Pherusa living in the English churchyard beetle, were found in fecal discharges, and many authors have recorded the presence of dipterous larvae in the alimentary canal.

The majority of such observers have inclined to regard these larvae as temporary endoparasites, and to consider that they have accommodated themselves to the conditions present in the human host. The cases seem to show that these larvae live for some time in the canal, and they often appear to evoke serious or even fatal disturbances; and yet the conclusions are open to grave doubt, for Caudoceleceus experimented extensively on two families of flies to which many of the supposed accidental parasites
belong, and found that the ingested larvae were regularly and promptly evacuated, dead or dying, and in no case did they secure a footing in the canal.

Among the myriapods about forty recorded cases of pseudoparasitism have been brought together and discussed by Mr. Land, in the larger majority the animal was taken from the nasal fossae, though in a smaller number it was actually obtained living from the alimentary canal, where it undoubtedly can exist for a brief time in spite of the untoward environment. The ingestion of such forms is purely accidental, the symptoms are those of helminthiasis in general, and their stay at most is very limited. They never show any evidence of adaptation to the new environment.

In some such accidental fashion other forms are sometimes ingested by various organs not connected with the alimentary system. Thus Trousseau reported the occurrence of a species of detritocell Sarcopoli in the human testicle where the mites formed an old colony in a painless cystic tumor.

In parts of the living animals of the types noted, the second class of pseudoparasites includes a large number of other structures which have been described as parasites. These may be considered conveniently in a few groups, the first of which includes bodies which are parts of the so-called host animal itself. Thus fragments of the arteria hyaloides have been described as eye worms (Filariae lenta, F. oculis humanae, etc.). The organisms of whooping-cough are nothing more nor less than ingested tissue, which subsequently are taken in as food, in distorted form, while groups of small auxiliary and intestinal glands, hydatid moles, and Pachecid bodies from the amnion have been frequently put on record as hydatid cysts.

Parts of substances used as food, both of plant and of animal origin, which have not been destroyed by the action of digestive juices are also among the pseudoparasites of man. The radulae of the common limpet have been reported several times from stools; the seeds of the apple, olive, and apricot and the wings of small flies in the alimentary canal, while groups of small, and glandular bodies have been also put on record as ingested substances.

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In determining the nature of unusual forms reported from the alimentary canal, it is always difficult to know whether the parasite is an active and aggressive parasite or an accidental parasite. In the latter case the parasite is not in the alimentary canal or some other cavity in the body of the host, or passively resting in the midst of the tissue of some organ.

While encysted parasites exercise a continued and sometimes serious pressure on the adjacent tissues, the draft on the host by free parasites is much the greater, and manifests itself in three ways. The parasite requires a certain amount of food for its support; this it takes directly from the host, either from that which the latter has digested or from that which it digests in the alimentary canal, or from material which the host has formed to perform certain work, as in the case of blood parasites, or from the tissue of the host, as in the case of some intestinal worms which feed on the cells composing the wall of the intestines. In any case the host expends at least the extra energy necessary to procure and digest the food taken by the parasite, and this extra labor will be directly in proportion to the amount of food taken, or in general to the size of the parasite and to its fertility.

In the second place, the parasite may require a certain amount of space, and correspondingly reduces the caliber of the tube in which it lives. Unless a considerable number of parasites are present this is hardly a practical stoppage for the alimentary canal, although in several recorded cases death has followed both the movements and the ingestion by the host of the alimentary canal or some other cavity in the body of the host, or passively resting in the midst of the tissue of some organ.

In the third place active parasites will, by their movements, give rise to a certain amount of irritation and inflammation of the membranes over which they move. This is in some ways, perhaps, the most serious trouble which a few parasites can cause, and it is much increased if, in the special case the parasite obtains its food at the expense of the tissues of the host, that is, if it tears or consumes the walls of the cavity in which it lives. A secondary, though possible, result of this manner of living is the liability of rupturing some blood vessel, with consequent serious results, as in the case of certain large flukes which may chance upon some large blood-vessel and in this way produce even fatal hemorrhage. In the alimentary canal a single ascaris may perforate the wall and induce fatal peritonitis, as has been observed several times in recent years. It is evident, then, that no more than a single active parasite may be present in the alimentary canal, for it is always some tax on the domestic economy of its host. Of course, the effect of a microscopic worm in the alimentary canal of an elephant will be so small that it
could hardly be calculated in any way; but this reasoning should not be extended too far. The disturbance produced in the human system by a single tape-worm is slight, and the prompt measures to remove it

Recent studies have demonstrated the presence of haemoglobin in the alimentary canal of many nematode parasites, the pathological effects of whose activities must be counted much more important than heretofore estimated by reason of this blood-sucking habit. Thus in cases of anemia the amount of blood lost from myriads of minute hemorrhages imparts a characteristic reddish brown color to the faces, the intestinal wall becomes seriously affected and affords places of easy attack for invading germs which, in a sense, the indirect damage may be very serious in the individual instance, and may include primarily or secondarily undesirable retrogressive or progressive histological changes, inflammatory processes, and disturbances in the circulation.

Another source of danger from parasites is one which has long been surmised but only recently demonstrated. A number of investigators have shown that various Cestoda, Acanthocephala, and Eumenatoda contain definite poisons which, when extracted and employed experimentally affect particularly the nervous system and the formation of blood. The continued formation and giving off of such a substance would explain the apparently excessive results of parasitism in some instances, notwithstanding the fact that symptoms such as have been noted under Argas (Arachnida), and Tenia (Cestoda). In a certain proportion of cases pernicious anemia is the result of this toxic effect, and is accompanied by a mortality of seventeen per cent., accident to man regarding Bothriocephalus. Whether the poison is elaborated by the parasite or is produced by pathological processes in the worm or by its death, as well as the ground for the variability in the toxic action of different specimens, are questions as yet undecided. It has been shown, however, that extracts from different species of heminthes vary considerably in toxic power.

Vaulthegard has isolated two toxic principles, one of which acts upon nerve centres and the other upon muscles, and many symptoms produced experimentally by the injection of these substances are analogous to those manifested in parasitic disease. According to this chemical theory, the troubles caused by parasites are due to the formation of toxic substances more rapidly than the host can eliminate them, and their consequent accumulation in the system. It is noteworthy that eosinophila has been recorded as a frequent if not universal symptom in parasitic infections. From 15 to 50 per cent. of eosinophiles in trichinosis, and 10 per cent. in echinococcus, and 20 per cent. in ascidian infection are average figures. The percentage varies greatly and does not appear to be constant, while it is present in other pathological conditions as well.

Life History.—Normal parasitism is related to the life history of the parasite with peculiar intimacy. Among accidental parasites the animal seems to continue the usual method of multiplication under the changed conditions. Thus Occley was able to colonize Lepidoptera pellic in the vaginae of mice where they reproduced normally. But in case of the well-known Rhoboboeum nigromham in of the frog the parasitic generation alternates with a free living generation, and the two are distinguished only slightly in structure but radically in method of reproduction, since the one is direct and the other hermaphroditic. In the case of the parasite of Cochsin China dysentery also, Strongylodes stercoralis, there is a hermaphroditic parasitic generation and a dioecious free-living generation, in which the individuals differ noticeably from the first. Alternation of generation is not infrequent among true parasites, but it usually bears a different relation to the life history, and one which will be clear after the examination of the simpler cases.

In the simplest case which is exemplified by many of the nematodes parasitic in the urinary canal the eggs reach the exterior with the feces of the host, and in them or in water undergo development until after a brief period of growth, either still enclosed in the protecting egg membranes, as is the case in Ascaris lumbricoides, the common stomach worm, or as a free-living form in water, the larva is ready to be reintroduced into the human alimentary canal. Then it undergoes its transformation into the adult, which is usually only growth, and the formation of the reproductive organs which are presaged in the larva in the form of a single cord or group of cells near the centre of the body, often so insignificant in the undeveloped condition as to escape observation. This type of development may be somewhat complicated by the location of the parasite in one region of the canal, where it passes through the earlier stages of development and becomes sexually mature before seeking its definitive location. Such is the case in the pinworm, Oxyurus vermicularis, which grows to sexual maturity in the cecum, while the larva migrates to the rectum in order to make perfect excursions to the perineum for oviposition.

A more complicated development is illustrated by the Guinea-worm, Dracunculus medinensis, in which the embryos are shed out in a very advanced stage of development in the body of a new host where the mosquito is biting. In Trichinella spiralis the encysted larvae in flesh are set free in the stomach by processes of digestion. They wander into the duodenum, and after attaining sexual maturity the female penetrates a villus and sets free the embryos which, reaching the wall of the host, engage in the development of the blood current, encyst there and await transference to a new host. Thus in both cases no part of the history takes place in the external world, and the transfer of the parasite is dependent upon the carnivorous or omnivorous habits of the animal. In the first case the one case is primary, and the other alternately as primary and secondary, but in different organs.

A still more complicated relation is found in the majority of Trematoda and in some Cestoda when the change of host is associated also with an alternation of a sexual with an asexual generation. In most Cestoda the eggs develop into an embryo which in the secondary host gives rise by metamorphosis to a peculiar larva, the bladder-worm; and this after its transfer to the primary host develops into the adult tape-worm. The relation between primary and secondary host here is generally that of food and feeder. Thus the bladder worms of the two most common human cestodes are found in the flesh of cattle and hogs respectively, and develop when introduced into the alimentary canal of man into the adult tapeworm. Though somewhat complicated by radical changes in form, the process is generally regarded merely as a metamorphosis. The case is somewhat different in those forms, as, for instance, Taenia echinococcus, in which the bladder worm proliferates, forming not a single head merely, but several or many, from each of which when introduced into the proper host there may develop an adult cestode. Here the larva in the secondary host multiplies asexually, while the adult in the primary host

504
Parasites. 

Cysticercus very introduced eggs containing various of the nation host, chance cles nation which individual, suffice the generations been accompanied the infection, which has been introduced during preparation to conditions such as to the larvae. This method of infection, namely, the introduction of encysted larve, is characteristic for the Cestoda. Those species most common as adults in man among civilized nations are obtained directly from artic les of food, as Trichinella spiralis from beet, Dibothriocephalus latus from fish; other less frequent species as Hymenolepis diminuta, Dicrocoelium dendriticum, and others of which the larval stages are found in insects (cockroach, beetle, meal worm) ove their introduction perhaps to the changes of the infected objects in bread, puddings, or other similar articles of food.

Disgare of personal cleanliness on the part of the individual, the habit of biting the finger-nails, and among children the practice of sucking fingers or toes serve to infect such with the eggs or embryos of many parasites or to increase an infection already acquired. In this way there is introduced the larve of Diphyllolotis canina, which lives in the dog and cat, the eggs of Ascaris lumbricoides, the dog and cat round worm, eggs of Oxyurus vermiculosus of the cat, and isolated uninfected larve of the host, eggs of Cysticercus celolophae when the adult is present in the same host, and many other species. Contamina tion of hands with eggs from dirt and consequent infection of the individual is common in children and field laborers, and may introduce any form of which the eggs are capable of causing the direct infection; these forms are Ascaris lumbricoides, Trichinella spiralis, and other Nematoda. 

The introduction of eggs and embryos takes place in the majority of cases by the contamination of the water supply. Almost all the eggs of the helminthes develop in standing water, and primitive methods of obtaining drinking-water from pools afford the best means of disseminating the species. Salads and other foods are found served from infected water basins, especially in those regions where it is customary to use human excrement to enrich the soil, or where the water supply of the village is dependent upon infected sources.

Of the important parasites which reach the human system as eggs in water or on uncooked vegetable food are of the Cestoda: Cysticercus cellulosae, the larve of Taenia solium, Echinococcus polyacanthus, the larve of Torni echinococcus; of the Nematoda: Ascaris lumbricoides, A. canis, Oxyurus vermiculosus, Trichocephalus trichiurus; of the Linguittulida: Proteostoma duodenale, Parocephalus konstitchens. 

Of those which as larvae attain the human host in the same manner one may list all the Trematoda parasitic in man, and of Nematoda Strongyloides stercoralis and possibly Uncinaria duodenalis, though according to the studies of Looss the latter seems to bore its own way actively into the body of the host.

The part played by chance in the introduction of parasitism is very small so that cats, hairworms, maggots, and even tapeworms have been taken from wells and from running water. The same forms occur frequently in various kinds of fruit; others in old or carelessly handled meat, also milks in cheese and fruit; and any or all of these may at times reach the human alimentary canal, where according to their adaptability they become occa sional, accidental, or pseudoparasites. Their presence may be made known at once by adverse conditions, or they may remain long undetected so that their nature is wholly unknown. They may reach peculiar locations, as is shown by the flesh fly maggot taken from an abscess in the middle ear, which it had in all probability reached by active migration through the Ethmoid tube, having been introduced into the throat with a piece of meat, or by the impure water supply which semi-civilized communities are wont to draw from the nearest pool. The minute, well-protected eggs of parasites distributed in fecal matter everywhere (for such matters are not) exacting in their demands for the disposition of women are carried by rain water and distributed over large areas contiguous to the settlements and contaminate generally the surface water of the district. In case the parasite develops directly, the human host becomes infected by the use of this surface water; and it is in a form requiring a secondary host, the same conditions give it easy access to the forms which serve as such, since these are largely domestic animals. The close relation of the abundance of the eggs to the presence of infected animals is the case of Bothriocephalus latus. This form is very common in a few regions in Europe, all of which are proximate to bodies of water. The intermediate host is a fish, and the very means adopted by civilized communities for removing danger of contamination from waste, namely, the sewage system, became the medium through which the eggs and embryos were carried into the lake. There they found suitable secondary hosts in the fish which subsequently reached the city markets further to infect the populace. The life cycle was completed within the geographical limits, and the element of chance which plays a large part in limiting the numbers of parasitic animals was reduced to lowest terms.

The dangers of parasitic infection in communal life, which pays little attention to the amount or frequency of surrounding surface water, is also illustrated by the spread of malaria, elephantiasis, and yellow fever, which depend upon the abundance of mosquitoes bred in this casual water. It has been abundantly shown that even flies of small numbers may multiply in the最infectous of water basins, and that the contamination of the sewage system, became the medium through which the eggs and embryos were carried into the lake. There they found suitable secondary hosts in the fish which subsequently reached the city markets further to infect the populace. The life cycle was completed within the geographical limits, and the element of chance which plays a large part in limiting the numbers of parasitic animals was reduced to lowest terms.

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industrial success are met by regulations which cure the evils referred to. All remnants are used and are subjected to processes which destroy whatever parasites may be present. Under these regulations and may safely predict the gradual disappearance of parasites, especially with the co-operation of certain factors not yet mentioned.

In addition to municipal features as noted, personal habits play an important part. Cleanliness of person and hands, coupled with careful abstinence not only of the person but also of the various articles of food, reduces the percentage of parasitic infection. A simple infection of *Trichoscephalus* becomes manyfold greater by the accidental transfer of eggs from the skin near the anus, where they are deposited, to the mouth. The reality of such supposed auto-infection is proved by the high degree of infection among insane and defective classes which are known to exercise little care over personal cleanliness. No doubt many eggs of parasites are introduced on salads and other uncooked foods which are eaten without sufficiently careful cleansing previously.

The employment of footgear and hand coverings is frequent also, because it reduces directly the likelihood of infection from eggs of parasites contained in earth, etc., which with uncovered hands become temporarily imprisoned beneath the finger nails of the field laborer. These coverings may also play a considerable part in preventing infection with *Taenia*, but that the observable outbreak of Looss are confirmed that the larve enter the body by an active migration through the skin, chiefly of the hands and feet, with which they come in contact in the case of field laborers.

Probably more influential than any other factor in determining the reduction in degree of parasitism is the use of cooked food. A large part of the flesh food of mankind is cooked, and in this raw condition which condition the larval parasites are capable of development to the adult on reaching the alimentary canal of the new host. Were all animal food eaten only when thoroughly cooked, the dreaded *Trichina* would cease to have clinical importance. The abundance of *Tena nigra* , the beef tapeworm, where beef is eaten raw, of *T. solium*, the pork tapeworm, where raw ham is a delicacy, and of *Diothele acantha* , the broad tapeworm, where partly cooked fish is eaten uncooked, furnishes the demonstration of the proposition advanced. And so long as pork is eaten uncooked cases of trichinosis will occur; whatever means may be taken to reduce the danger by meat inspection. That factor which is about to be considered is destined to play the greatest rôle in the limitation of parasitism: it is the intellectual, and by it is brought about the determination of a rational hygiene and its application by the individual. National prejudice or established custom comes into operation which boils and belies, and it must ultimately succeed in reducing to lowest terms the parasitic infections of man and the important food animals.

Henry B. Ward.

BIBLIOGRAPHY.

References to the important works consulted may be found under the various titles in their relation to Human Pathology, Nematoidea, Protozoon, and Trematoda.

**PARATHYRIODS.** (NORMAL AND PATHOLOGICAL ANATOMY.)—In 1880 Sandström discovered the presence of small glandular organs on the posterior surfaces of the lateral lobes of the thyroid. He found these to be of constant occurrence, and from their structure regarded them as embryonic thyroid tissue; he accordingly named them *parathyriod*. Under these conditions and may the organs were independently discovered by Stieda in embryos of the pig, and by Baber in different animals. The former regarded them as carotid glands, the latter as embryonic thyroid tissue. But little attention was paid to these glands until 1881 when Goebel, under the influence of the discovery, in the four years immediately following, his statements were supported by numerous observers. In 1895 the first careful study of the minute anatomy of the para-thyroid was given by Schaper. Numerous experimental investigations followed, both in normal and thyroidectomized animals, showing the physiological importance of these structures. Various names have been proposed for them: "epitheliod bodies," "accessory glands," "accessory thyroids," "glomerules thyromes," etc.; the original designation *parathyroid* has the advantage, however, that the organs are not thereby confused with the accessory glands having the true thyroid structure.

As to the physiology of the parathyroids and their function no absolute knowledge has yet been obtained. It was first believed that they had a direct connection with the thyroid, and could compensate for it. Later experimental investigations in transplantation and extirpation, as well as in feeding with gland substance, have shown that this the observation of Looss is confirmed from that of the thyroid. The loss of the thyroid leads to a chronic disease, that of the parathyroids to an acutely fatal disease. Feeding with gland substance is effective only in cases of the administration of the same gland substance as that of the one being affected. This is of value only in case of the loss of the thyroid, and parathyroid feeding only in case of loss of the parathyroids. In transplantation, both thyroid and parathyroid preserve their characteristic structure.

The various investigations are not yet agreed as to the embryology of these glands, but it may be regarded as proved that the parathyroid bodies lying outside of the thyroid have an independent *Autogene* in the fourth gill pouch. In some animals there occurs constantly an epithelial body included in thyroid tissue, which probably arises from the third gill pouch. This internal epithelial body occurs so rarely in man that its presence may be regarded as a probable anomaly of development. Further, the parathyroids arise from single symmetrical *Anlagen* and their characteristic multiplicity is to be ascribed to a secondary snaring off.

The parathyroids occur usually in pairs; sometimes one on each side, or two on one side and one on the other. The writer has the commonest case of one of the anterior number observed has never been greater than four.

In size they vary greatly, but they are usually very small; the average, as found by the writer, being about 7 mm. long, 2-3 mm. broad, and 1.5 mm. thick. The average weight is about 0.2-0.3 gm. They are often almond-shaped, having one end recurved; but the shape not infrequently suggests the spleen. At other times they may be flat, cylindrical, or round. Their color is usually pale brown, but may be brownish-red or bluish, so that they are easily mistaken for lymphoid glands. They usually lie behind the lower poles of the lateral lobes of the thyroid, separated from the thyroid tissue by connective tissue, their convex surfaces lying in slight depressions on the under surface of the lobes. Not infrequently they are situated in the posterior portion of the parathyroids, their brown color becoming more prominent in contrast to the white adipose tissue about them. By following up the branches given off from
Trematoda
Petrus Servius reported the first case as occurring at Rome.

Kuchenmeister, up to the year 1888, collected 149 cases. The majority of these were discovered in the anatomical laboratory and on the post-mortem table. Pie in 1895 increased the number of reported cases to 190. Lochte up to the year 1894 collected 13 cases of partial transposition of the viscera. In more than half of these very poor descriptions were given.

An attempt to collect all the cases of situs viscerum inversus is extremely difficult and unsatisfactory, because they are reported in the literature under numerous headings. Perhaps something like 500 of these cases have been reported.

Until recent years cases of transposition of the viscera have been discovered, studied, and reported chiefly by anatomists and pathologists. Judging from my own personal experience with these cases, and from that of a large number of prominent clinicians and anatomists to whom I addressed letters of inquiry regarding their experience with transposition of the viscera, it would seem that the pendulum has swung about of late years, and that now a much larger percentage of cases of transposition is discovered by the clinician. This fact is a natural result of the much more frequent and careful physical examinations that are now being made. However, even with this improvement, all physicians know that a very small percentage of even sick people submit to careful physical examination, and that the percentage of the entire population who are thus examined is extremely small.

Since the spring of 1897 I have seen in hospital and private practice six cases of transposition of the viscera. It is rather a remarkable fact that three of these cases were seen within the short period of six months. I am also personally familiar with three other cases of situs inversus, discovered in the living subject by members of the internal medical staff of the University of Michigan, two by Dr. Warthin, and one by Dr. Cowie.

These cases have been reported in detail in the American Journal of the Medical Sciences, November, 1902, and in the Vaughan Postekrift, 1903.

In reply to my letters the following facts were gleaned: Five well-known internists and four professors of anatomy had never seen a case of transposition of the viscera. In the remaining letters 37 cases were reported. All save 6 of these were discovered during life. In this country, at least, cases of transposition are nowadays much more frequently discovered during life than after death. Note the contrast between Graber's report and my own. Of his 79 cases only 5 or 6 were discovered during life. In my collection, which simply covers the cases reported in the letters referred to, together with those with which I am personally familiar, are 46 cases, of which 40 were discovered during life.

Method of Examination.—Careful inspection, palpation, percussion, and auscultation of the chest are of course prime essentials. The failure to find the heart apex and heart dulness on the left side most often puts one on the right track. A careful examination of the right chest may then reveal a dextrocardia. This is at once a key to the physical condition. An absence of liver dulness is then detected in the right hypochondrium. It is sought for and discovered in the left hypochondrium; the splenic dulness will then be found in the right midaxillary line.

The position and outline of the stomach may be demonstrated by inflation or by the use of the gastrophotograph; the same is true of the sigmoid. X-Ray examination of the heart with the fluoroscope easily demonstrates the right-sided position of this organ. (See Fig. 477.)

Theories Explaining the Development of Transposition.—These are chiefly of interest to the embryologist and anatomist, and will hardly be understood except by those who have devoted special study to embryology. The following are some of them.

Von Baer explains transposition by the turning of the embryo in the opposite direction; that is, the embryo normally lies on the left side of the umbilical vesicle; but if it lies on the right side, then we have transposition. According to him this occurs at the beginning of the developmental period.

Förster considers situs inversus a malfunction in which the transposition of the amnion takes place in the first embryonal formation. In the double monster the fetus of the right side shows a complete transposition, while the fetus on the left side shows a normal situs.
Rindfleisch believes that a spiral turning of the blood column is responsible for the displacement of the heart. Normally it flows from left to right, but in situs inversus an opposite direction must obtain. The asymmetry of the heart is made responsible for all asymmetry in the abdominal body.

Virchow emphasizes the influence of the umbilical cord. In situs inversus it is wound spirally to the right; in situs solitus to the left.

Kolymann thinks that the location of the fertilized germinal disc at the surface of the egg is the essential thing. The normal situs in single birth probably depends upon growth of the germ from below upward, instead of from above downward. He says that from this it follows that the condition of the umbilical cord is not due to rotation of the embryo; it has been inverted. This must also affect the later spleen side and the side of the arterial heart. Concerning the congenital partial situs viscerum, solito inversus, which shows itself either in the chest or in the belly, but not in both places at the same time, he believes that the growth on the whole follows the type for the situs inversus. The rarer partial situs is an inhibition formation which grows according to the type of the normally projected embryo.

Marchiotti in the situs transversus of the single born emphasizes the lungs wedged in ofomphalo-mesenterica, first mentioned by Darette. The direction which the heart loop takes depends upon the dissimilar growth of the two halves of the vascular area. Under normal conditions a dissimilar formation of the two halves exists. The left omphalo-mesenteric vein is more developed than the right: the right gradually disappears. The heart reverts in a very sensitive way toward the cause of situs transversus.

Marchiotti says that the loop formation of the vena omphalo-mesenterica about the intestines under normal conditions prevents the intestines from slipping toward the right. So a right turning takes place if the loop formation is absent. He considers a left-sided persistent vertebreae the best evidence that the turning of the embryo is not due to rotation of the stomach. In a more recent monograph Marchiotti states it as his belief that the development of the vena omphalo-mesenterica can have no influence upon the rotation of the stomach.

Lockhart mentions the view that the growth of the organ considered in the sense of situs solitus is associated with a persistence of left-sided omphalo-mesenterica and umbilical vessels, while those of situs transversus totally, on the other hand, are associated with corresponding right-sided correspondence.

To the clinician transposition of the viscera presents many interesting problems in differential diagnosis. The displacement of the heart to the right makes it necessary to examine the lungs and pleura carefully, in order to exclude any required displacement. The discovery of an enlarged area of dulness in the left hypochondrium suggests a number of possibilities. It is most likely an enlarged spleen—either of leukaemia, malaria, splenomegaly, or some other disease. This point is illustrated by actual cases in practice. In Munson's case the diagnosis of an enormously enlarged spleen had been made; and the displacement of the heart was thought to be due to dilatation.

In the normal patient it is a very common experience to find an entire absence of liver dulness in the right hypochondrium. It is also common to find that the apex beat is neither seen nor felt on the left side, especially if the patient is quiet and in the horizontal position. Heart dulness is also frequently absent. So it is easy to understand how these cases of transposition often are overlooked.

It is possible to mistake an aneurism of the arch for a dissected heart. This fact was recently brought to my attention.

Gruber refers to the following errors in diagnosis. In one case of transposition a pulse in the right hypochondrium led to the diagnosis of a chronic inflammation of the liver. In another case a soldier was wounded in a duel, the right hypochondrium; the position of the wound and the vomiting of green fluid it was thought that the liver had been penetrated. In a third case, in the Würzburg clinic, the transposed liver was diagnosed as a spleen tumor. In a fourth case, one of cancer of the pylorus, in a transposed stomach, the hard tumor felt deep in the left hypochondrium was thought to belong to the left part of the stomach or the pancreas.

In appendicitis developing in a patient with transposition of the viscera the signs and symptoms would of course be located on the left side, or on the right side. The surgeon would choose Monroe's point instead of McBurney's point for the site of his incision.

Gruber arrived at a number of interesting conclusions from a study of 79 cases. Concerning the sex there were 49 men, 20 women, and 11 in which sex was not mentioned. These individuals lived as long as those with normally placed organs. Five of the 19 women lived to an age between seventy and eighty-four.

The women were generally fruitful. One gave birth to twine children. Among the 20, 4 died an unnatural death, and only 4 were extremely malformed. There was transposition of both chest and abdominal organs in 71; of the abdominal organs alone in 8. In the first kind the transposition was complete, in the latter incomplete. In 3 cases it was not transposed; in 2 both lungs had two lobes; in one the right had one lobe, and the left two lobes.

Curvature of the dorsal portion of the spine is mentioned in only 11 cases. In 7 of these it was to the left, in 4 to the right as normally.

We cannot draw the conclusion that persons with transposition are more likely to be left-handed than those with normally located viscera.

The position of the testicle was mentioned only 7 times. In 4 the right was lower, in 1 the left. In 1 the left had not descended.

The lower position of the right testicle is unimportant as a sign of situs inversus. In only 9 cases were there notes on the position of the kidneys. In 7 the left was lower, in 2 the right.

In 32 cases in which the vessels arising from the arch of the aorta are mentioned, these were transposed 29 to 30 times.

II. Steinhauser mentions the fact that in the operation of esophagotomy, it is well to know that the esophagus lies over the right trachea in persons with transposition. In situs partialis the transposition of the abdominal organs may be very irregular in one case the stomach and duodenum were normally located, while the other organs were transposed. In another case the liver alone was transposed.

1888 a case of pure dextrocardia with congenital pulmonary stenosis, without malposition of the viscera in general, was shown to the Vienna Medical Society by Dr. Gruss. In discussing the case, von Bamberger concurred in the diagnosis, and remarked that Professor Schlüter had lately stated that no single case of pure dextrocardia had ever been proved, whereas all anatomists of experience, for example Rokitansky, Friedberg, Förster, et al., had mentioned such cases, and he himself had seen two.

The above quotation emphasizes the fact that partial situs is a much rarer condition than complete. If the transposition is located in the abdominal cavity, it will most likely be overlooked in the physical examination.

James Rae, Arnold, Traumatol., Trematoda.—Iodoform, orthoiodo isobole, C.II., CI.1.0.—is a reddish, odorless, insoluble powder which is used as an antiseptic substitute for iodoform in wounds and ulcers. It is an efficient drying powder and deodorizer.

II. A. Postelo, Trematoda. 8.—The class Trematoda, or Flukes, constitutes one of the prominent subdivisions of the

* A general discussion of parasitism and its effects is to be found under the heading Parasites.
branch or phylum Plathelmintes, the characteristics of which were outlined under the Cestoda. The group was recognized as distinct in 1850 by J. G. H. Zoster, a practising physician in Germany, who with great clearness of vision separated the then accepted class of Helminthes into insect worms and five groups of closely related forms. These groups received in 1859 at the hands of K. A. Rudolphi, the celebrated Berolinian naturalist, the scientific names of Nematoda, Acanthocephala, Trematoda, Cestoda, and Cyclostomata. The latter have since been shown to be immature stages of the Cestoda, and C. Vogt in 1851 demonstrated the unnatural character of the association. Thus in making a natural group the flatworms in which are now included the flukes, the tapeworms, and the free living flatworms, are three great classes of the phylum designated Plathelmintes.

In certain features, such as the size, body, the presence of an alimentary canal, and in some cases even of special sense organs, the Trematoda stand much nearer the free living forms than the Cestoda, although all of the species included in both classes are parasitic. The consistent parasitic habit, in which the tapeworms, is varied by a modification in degree among the flukes which serves to show their relation also to free living animals, and contrasts strongly with the intensive endoparasitism of the Cestoda. Thus among the flukes there are not only the true parasitic species, but also such as are ectoparasitic and preserve in some degree those features of free living forms that are lost with the change for a parasite. The assumption of endoparasitic existence is a well-defined one, and manifests greater uniformity in structure than the Cestoda, while it also embraces both fewer species and fewer human parasites than the latter class.

In form the Trematoda are generally flattened and elongate, more rarely cylindrical, conical or irregular, with plane ventral surface on which are located the sexual pores and arched dorsum. The mouth is at or near the anterior tip of the body and the excretory pore is similarly related to the posterior end. The mouth is nearly always surrounded by an oral sucker, and other suckers may occur on the ventral surface, at the posterior end, or more rarely on the margin or dorsal surface. In connection with the suckers ciliated hooks or anchors are found as additional organs of attachment, and the exterior of the body is often covered more or less completely by scales or spines of varying form and size. Most flukes are comparatively insignificant in size, measuring only a few (1 to 15) millimetres in length, though rare species largely exceed both limits.

A cross section shows that a body cavity is wanting. The trematodes belong to the group of forms in which the space between all organs is filled up by parenchymatous tissue, giving a firm consistence to the mass. The exterior is bounded by a homogeneous membrane of varying thickness known as the cuticula, which actually is formed by the fused bases of cells lying deeper in the tissue, but which presents the appearance of a basement membrane continuous with that of the tegument. Trematodes were believed to be without an epithelial covering in the adult condition. As a matter of fact the pyriform epithelial cells lie in bunches between or within the diagonal muscles, and are connected by numerous fine processes in the so-called cuticula. Some of these cells are especially developed as unicellular glands.

The dermo-muscular sac lies just within the cuticula and consists of layers of circular, longitudinal, and dorso-ventral muscles which are inserted on the cuticula. Special development of the muscular layers is found in the suckers, which consist of muscular fibres extending in three directions and designated as equatorial, meridional, and radial; these correspond to the circular, longitudinal, and dorso-ventral muscles respectively lying in the special set of muscles radiating from the sucker through the tissues. In certain cases at least special muscles are developed in connection with the reproductive organs, with the hooks, and even with the surface spines, as in the common liver fluke. The more highly specialized forms of the trematodes have developed to a high degree, a set of muscles more or less extensive, which combine to make the form of the flukes extremely mobile and variable. Locomotion is achieved by means of the body musculature and the suckers, aided in rare cases by the sucker spines already mentioned.

An alimentary canal is always present and forms the ultimate distinctive feature between Trematoda and Cestoda. In all cases it has but a single opening, the mouth, which lies at the anterior tip of the body, or more rarely on the ventral surface surrounding another foramen through which is surrounded by the oral sucker (Fig. 4772). In lower members of the group, two or more suckers may lie near the oral opening or the latter may be entirely unarmored. In form the alimentary canal may be rhachidian, though often not so, and serves as the food canal for the embryo. In the latter case one can distinguish an initial unpaired region variable in length, which extends posteriad from the oral opening and is called the esophagus. It is thinned and not digestive in function, though frequently may be more or less glandular. It is connected with the hepatic duct within the liver. In the latter case one can distinguish an initial unpaired region variable in length, which extends posteriad from the oral opening and is called the esophagus. It is thinned and not digestive in function, though frequently may be more or less glandular. It is connected with the hepatic duct within the liver. It may serve as an aid in the ingestion of food.

The simple esophagus divides into two intestinal curae (J, Fig. 4772), which form the digestive and absorptive region of the alimentary canal. They are blind sacs, usually symmetrically placed right and left, but of variable length and character. In some genera they are short and do not reach the sides of the body; in other cases they extend to the posterior end, and may even be connected by several common ducts or stigmata. Usually the curae are of uniform caliber throughout, and yet in some genera they manifest an irregular wavy outline, or even possess numerous lateral diverticula which may branch again and give the system a dendritic aspect. The endoparasitic forms subdivide on the internal contents and secretions of the host, but also ingest epithelial cells and blood, thus giving rise in some cases.

![Fig. 4772. Ophthalmia's alimentary tract.](After Looss.)
to severe hepatic or intestinal disturbances, the gravity of which is proportionate to the extent of the invasion.

The excretory system agress in general with that of the Cestoda. One finds a variable number of primitive nephridia or "flame cells" (Fig. 4774), scattered throughout the tissue. These cells are stellate in form, with a lumen which may be either a cilia which lie on one side in a narrow canal. The constant motion of the cilia simulates the flickering of a candle flame, whence the name. The tubules from these flame cells unite into larger ducts, and ultimately combine into a single vessel, which opens at the posterior end of the body by a single excretory pore (p, Fig. 4774). The final vessel may be short and expanded, or a longer median canal. In both cases it apparently functions as an excretory reservoir or bladder (Fig. 4774.).

The nervous system is poorly developed in accord with the parasitic habit of the group. It consists of two small lateral aggregations of ganglia which lie near the pharynx which are joined by a ring of fibres that encircle the esophagus, and of nerves extending anteriorly and posteriorly from these ganglia. The three pairs passing anteriorly are short and innervate the oral sucker with adjacent dermal areas, muscles, and primitive sense organs. The posterior nerves form dorsal, lateral, and ventral (p) pairs. The ventral nerve cords are much the most prominently developed; they join each other near the posterior end as do also the dorsal cords. Circular commissures at somewhat regular intervals unite all three pairs of nerves, and ganglion cells occur most frequently at the points of union, though also rarely elsewhere in the course of the nerves. A dorsal nerve plexus is at least often present, and stands in immediate connection with the main nerve trunks. Sense organs, of the most primitive sort, occur in the skin, while in the free swimming larva as well as in cestodiform forms simple eye spots are found. Other sense organs are not known.

Reproductive System.—The Trematoda are all but universally hermaphroditic, and possess highly complicated organs of reproduction. One of the human parasites illustrates the rare secondary condition of separate sexes, and will be considered under the appropriate heading; here it is sufficient to outline the general conditions.

The testes (T, T', Fig. 4772) are usually two in number, symmetrical in size and location, although there may be but a single one, or on the other hand a series of several. These organs are commonly round or oval in outline, with frequent variation toward a lobed condition, or even to a dendritic form. The two vaginae unite sooner or later into a single vas deferens, which may or may not possess an enlarged region used as a seminal vesicle. The duct opens on the surface of the body, or into the excretory canal at the excretory pore, and the terminal portion of the canal may form by eversion a protrusive copulatory organ. More frequently this region possesses a highly developed muscular organ known as the cirrus, and this with or without the seminal vesicle may be the so-called cirrus pouch, and provided with unicellular glands (prostata). When highly developed this copulatory apparatus forms a conspicuous organ, and, as has recently been elucidated by Looss, constitutes a valuable taxonomic character.

The female reproductive organs show an unusual specialization in the separation of the germarium, often incorrectly denominated the ovarium, from the vitellaria or yolk glands. The germarium (G, Fig. 4775) is small, located ordinarily in front of the testes, and usually round or oval in outline, although it may also be dendritic in form. The vitellaria are paired, highly lobed or dendritic in form, and extended usually along the sides of the body laterally continuous, and in both cases it appears that functions as an excretory bladder (p, Fig. 4774). The short germ duct, coming from the germarium, and the common yolk duct, unite to form a short, slightly expanded tube known as the ootype on the sides of which are found unicellular glands, often crowded together into a mass and collectively denominated the shell gland (Sp, Fig. 4775). From the ootype a short inconspicuous canal rises to the dorsal surface; this organ, called Laurer's canal (L. C.), is clearly rudimentary, and its significance is not beyond dispute, although it is usually homologized with the vagina of cestodiform forms; and, according to recent observations, still functions as such in rare cases. It may be near the proximal end a bulbous lateral expansion, the seminal receptacle (D). The ootype expands immediately beyond the shell gland to form the uterus (U), which as a long convoluted tube fills the major portion of the body with its coils crowded with opaque brown-shelled eggs. In the posterior part of the uterus (Fig. 4775) lies near the ootype there is usually a mass of sperm, so that the region has been called the uterine seminal receptacle. The uterus terminates in short heavy-walled region devoid of eggs, known as the metra. This lies alongside of the cirrus pouch, and opens at the female genital pore on the surface of the body, or into the genital cloaca and serves to receive the cirrus in copulation. In these forms cross fertilization is the rule, and cases have been observed in which one individual only functioned as the male as well as such in which both were thus functional. In a few instances self-impregnation has been found. The genital pore lies nearly near the ventral sucker, or between it and the fork of the alimentary canal; but a marginal position, or one near the oral sucker, or even at the posterior end of the body, is also to be found.
In the arrangement of the reproductive organs one finds the double condition designating the two amplatypes, in which one individual is, as it were, the mirror image of the other. Usually one can be designated as having the normal arrangement, but the relative frequency may be such that neither can be said to be more typical than the other. Such a reversed arrangement was first observed among the Opisthorchidae, where it seems to be very common; it has also been shown to exist among the Dicrocoeliinae, and the difference in Paragonimus Westermanii referred to later (Figs. 4782, 4784) may be explained in the same way.

This description obtains for the endoparasitic forms, particularly for the Fasciolidae, which are of especial importance here. In other families, especially among the ectoparasites, somewhat radical differences from the plan outlined may be observed.

The egg of the Trematoda is more or less oval or ellipseoidal, rarely flattened asymmetrically. It is provided with a heavy chitinous shell which is transparent when first formed, but darkens soon in the first cells of the uterus to a deep yellowish-brown, which is almost entirely opaque. In endoparasitic forms the egg shell possesses a polar filament by which it is attached when deposited; but this is not present in endoparasitic forms. At most one finds an irregular, insignificant protuberance at one pole, such as is present in Schisotrema harnatobuna. The shell regularly possesses a cap or lid which is sprung at the appropriate time to allow of the escape of the enclosed embryo. Such eggs may be found in the waste of the body, excreta, or sputa, or may occur adventitiously in various tissues. Under such circumstances they have in the past been diagnosed as cercidia.

Development. — When first formed the shell contains the single fertilized egg cell surrounded by a mass of highly granular yolk cells. The latter may be distinct or may be already broken down into an indistinct granular mass. This serves for the nutrition of the embryo during early development. The cleavage of the fertilized ovum begins at once, and ordinarily proceeds so as to bring the embryo to development at the time when the egg, extruded from the uterus of the parent worm, is carried into the external world with the waste products of the host. This is simple since the normal seat of the parasite is the alimentary canal, or some of its outgrowths, liver, lungs, etc., and the eggs are distributed with sputa, faces, or rarely urina.

The modified environment brings about the opening of the egg shell and the escape of the embryo, which follow experimentally when the ripe eggs are brought into water at suitable temperature. The embryo (Fig. 4776), which is designated a miracidium, is somewhat elongated in form, with a conical tip, and sometimes also a sharp boring spine at the anterior end. The ectoderm is composed of large cells and is ciliated. One may distinguish also a pair of flame cells (F. c. Fig. 4776), or primitive excretory organs, and a rudimentary X-shaped eye spot (e). In the interior the cells are smaller and are arranged irregularly about a cavity into which they are set free singly or in groups. These do not become prominent until the miracidium has attained its location in a new host, and this, which it seeks at once on emergence from the egg shell, is almost universally a mollusk. Embedded in the tissue of the mollusk, which is known as the secondary or larval host, the miracidium loses its coating of cilia, its eye spot and its special form becoming a mere irregular sac, now designated as the sporocyst, in which one finds egg masses crowding the cavity and developing into a new generation. In the ordinary case their form is that known as the redia, and when developed they escape from the sporocyst only to enter upon a similar method of reproduction, which gives rise to another new generation. In structure the redia (Fig. 4777) is characterized by an elongate form, a mouth with single oral sucker, a rhomboidal alimentary canal, two short locomotor protuberances, and an orifice known as the birth opening through which the new brood escapes.

This new generation originates as did that in the sporocyst from cells or cell masses set free from the wall of the cavity. The form developing therefrom may be a redia like that which produces it; more often it is still another new form, known as a cercaria, and in some cases the cercaria may even be produced directly from the first generation, the miracidium metamorphosed into a sporocyst or a redia. The form of the full-grown cercaria (Fig. 4778) is sufficiently characteristic to allow of its easy recognition. It is somewhat broader than the redia, possesses a central sucker as well as an oral, a trilobed alimentary canal, and an active caudal appendage for swimming, though in some forms designated as varieties of this stage this tail may be wanting or modified. The cercaria is in fact the young distance, supplied with an organ of locomotion when some part of the life cycle is to be spent in the open. Now, if not before, the young fluke is ready for the change of hosts which accompanies its attainment of the adult condition. The transfer may be passive or it may be associated with an active migration from the secondary host and a period of existence in the open water before the primary host is reached. Once that the latter is attained,
the tail of the cercaria is thrown off and the further development to the adult form is growth, chiefly of the reproductive organs which were present before only in rudimentary form. An encysted stage frequently intervenes. This the cercaria attains by burrowing into the tissue of some animal, or by settling upon the surface of some plant or other object. In the latter case the cyst is formed of the expressed secretion of glandular organs which hardens about the cercaria, which now has cast off its tail. In either event the digestive fluids of the final host are the means of liberating the worm from its cyst to enter upon the final stage of its career.

Great differences in detail are found in different species, but the following table, taken from Herzeg, exhibits in synoptic form the principal lines of development. Individual features connected with the species which occur as human parasites may be found under the appropriate headings. The entire process was formerly regarded as the true alternation of a sexual generation, the adult worm, with one or more asexual generations, sporocyst, and redia; but at present the reproduction of the latter is regarded rather as a premature parthenogenetic or parthenogenesis, and the alternation is called allidiogenesis. Some authors regard it, however, as merely a complicated metamorphosis, which is distributed over several generations. The transportation of the parasite from one host to another may be passive, as when the encysted form is eaten and set free in the alimentary canal of the new host by digestion, or it may be active in that the free swimming larva is engulphed with drinking-water by chance, or bores its way into the body of the water-inhabiting mollusk which it seeks out.

**Development of the Distomes.**

<table>
<thead>
<tr>
<th>Simple</th>
<th>Ordinary</th>
<th>Complicated</th>
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<tbody>
<tr>
<td>First generation</td>
<td>Miracidium</td>
<td>Water</td>
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<tr>
<td>Sporocysta</td>
<td>Host I (Mollusk)</td>
<td>Sporocysta</td>
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<tr>
<td>Second generation</td>
<td>Encysted distome</td>
<td>Host I</td>
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<tr>
<td>Third generation</td>
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Thus far only thirteen species of fluke have been listed as human parasites; they are as follows:

**Family:** Paramphistomidae.
**Gastroloboidea haimi.**
**Family:** Fasciolidae.
**Fasciola hepatica.**—Species recorded in United States of America.
**F. augusta.**
**F. buski.**
**F. buskini.**
**F. buskini.**
**Paragonimus westermani.**—Species recorded in United States of America.
**Opisthorchis felineus.**
**Opisthorchis sinensis.—**Recorded from man in United States of America.
**Opisthorchis viverrini.**
**Mesocestoides relictus.**
**Heterophyes heterophyes.**
**Dicrocelium lanceatum.**—Species recorded in United States of America.
**Family:** Merostomidae.
**Schistosoma intermediatum.**—Recorded from man in United States of America.

It thus appears that only five species have ever been found in the United States, and that but two of these have been recorded from the human host. It may be further noted that of these two, one (Schistosoma haematobium) was certainly acquired in other lands and probably has not gained a footing in our own, while the other is probably the true one, leaving for the human host not a single record of trematode infection originating within the limits of the United States.

The earlier stages in the life history, sporocyst and redia, occur only in mollusks, and the selection of the secondary host is somewhat narrow, so that not only is a direct infection from the adult fluke contrary to all experience, but also the introduction of the adult and the dissemination of the ova in a new region can only be followed by the permanent establishment of the parasite only when a suitable larval or secondary host is available.

The sheep liver fluke, *Fasciola hepatica*, has thus secured a footing in certain regions of the United States, and has become an important factor in the handling of domestic animals. It remains to be seen whether the human blood fluke, *Schistosoma homatoebium*, probably introduced from Africa to the southeastern States, and the Asiatic fluke, *Opisthorchis viverrini*, undoubtedly brought to the Pacific coast from the Far East, will establish themselves similarly to the detriment of the human species.

The encysted cercaria or immature distome occurs rarely in mammals, e.g., the pig, more frequently in amphibians and fishes and generally among invertibrates. The mature trematodes are parasitic only among vertebrates; the ectoparasitic forms inhabiting chiefly the skin or gills of aquatic species, and the endoparasitic forms occurring largely in the alimentary canal, though almost all organs may harbor them at times. Next to the canal, its accessory, the lungs and liver, are favorite seats of these parasites, but the latter are not wanting in the genito-urinary ducts, where in instances in birds they occur so frequently as to be occasionally enclosed within the egg shell during its formation and are subsequently discovered there. While the flukes usually move freely about in the cavity of the affected organ, they are in some cases more or less completely encysted in its substance. Thus the Asiatic lung fluke, *Paragonimus westermani*, is found in pairs in pulmonary cysts, and in rare instances such an association in pairs is connected with the secondarily acquired dislocating condition of the individual species.

The effects of parasitism have already been discussed (see *Parasites*); special features as well as means of treatment are treated under individual forms. The human parasites belonging to this group, as already recorded, are too few in number of species to call for a special key at an aid to identification.

**Taxonomy.**—Valuable recent work by Braun and Looss on the taxonomy of the group makes it possible to give a reasonable system. Only the parts dealing with human parasites will be particularly considered.

**Order Heterocotylea.**—Endoparasitic Trematoda with powerfully developed organs of attachment; excretory organs open separately on the dorsum; development direct. Only human parasites.

**Order Asphychoctylea.**—Endoparasitic Trematoda of simple organization with large ventral organ of attachment; excretory organs open by a single posterior pore; development direct. No human parasites.

**Order Metacotylea.**—Trematoda with one or two suckers, or rarely accessory lateral suckers also, for attachment; no chitinous organs of attachment. Intestine usually forked and mouth anterior; mostly hemoprotic with sexual pore ventral; excretory pore posterior. Always endoparasitic in vertebrates. According to mode of development divisible into two groups:
(a) Metastoma. Development without alternation of generations, but with two larval forms and change of hosts. No human parasites.

(b) Digenea. Development complicated by alternation of sexual generations (sporocyst, redia) with sexual generation. One or more changes of host. All human trematode families fall in a single large and varied group, viz.:Paramphistomidae, Fasciolidae, Schistosomidae.

The family of the Paramphistomidae is characterized by a terminal sucker, dorsal to which the excretory pore is located. The genital pore lies off the midventral line in the anterior third of the body; the pharynx is far forward and ordinarily designated the oral sucker; the intestinal branches are always simple, hermaphroditic. Only one genus is of interest here:

*Gastrodiscus* Leuckart. —Paramphistomidae with slender anterior region and large discoidal posterior region, which is concave ventrally. The small terminal sucker lies on the posterior ventral margin of this concavity. Pharynx with two outlet openings.

The type species occur in the alimentary canal of the horse and cattle in Egypt and India; one has been found parasitic in man.

*Gastrodiscus humanus* (Lewis and McConnell 1876). — (Syn.: *Amphistomum humanus* Lewis and McConnell 1876). Long, 5-8 mm. broad, reddish when living. Genital pore at bifurcation of intestinal cura. Eggs oval, 0.150 mm. long, 0.072 mm. broad.

The structure of this species is only imperfectly known. It has been found twice in Assam and India in the canals of natives who had died from cholera. Although present in large numbers in these cases Braun regards it as undoubtedly an occasional parasite, the normal host of which is as yet unknown. Giles, however, found it frequently in Assam, and according to 10,000 or more than twelve individuals in a single host, which militates against the idea that it was only an occasional parasite.

The family of the Fasciolidae is characterized by the presence of a ventral sucker, by the genital pore ventral, rarely lateral or terminal; always hermaphroditic, two testses, one germarium, with reteptaeulum seminis or Laurer's canal, or both, and with paired lateral often highly branched vitellaria.

The type species occur in the alimentary canal of the sheep especially, but it also occurs in many other ruminants, cattle, goat, horse, ass, deer, antelope, camel, as well as in the kangaroo, squirrel, beav- er, rabbit, guinea-pig, and man.

Life History. — The complicated development of this form has been elucidated chiefly by the researches of Leuckart and Thomas. The miracidium develops in the larval snail to a single young miracidium and then remains in water at the ordinary temperature to complete the development of the monad, which in the cercariae develops into a small egg laying set free seeks out a small snail (*Lymnaea truncatula* Müll. = *L. minuta* Drap.) that is commonly found in small pools or on partially flooded meadows.

The miracidium (Fig. 4776) attaches itself to some free edge of the snail, throws off its ciliary coating and then penetrates to the snail's liver, where it becomes a mere sac filled with masses of developing germ cells. This sac, known as the sporocyst, produces rediae, which remain in the same host, and sometimes give rise to a second generation of redia in the snail (Fig. 4777, A, B). The cercariae (Fig. 4777, C, and Fig. 4778), which are produced by rediae sooner or later, make their way out of the snail and encyst on blades of grass, with which they attain the final host in its food. The young distome set free in the stomach of the host is small, transparent, without separate regions of the body, and with only rudiments of the reproductive organs. It makes its way far up into the gall ducts of the liver and there attains its maximum size.

The life of the adult lasts probably not more than a year, but perfection of normal host takes place most commonly in the early fall or late summer. In the spring the eggs are most abundantly distributed over the meadows, with the excreta of the sheep. Lutz found that in the Hawaiian Islands *Lymnaea oahuensis* and *L. pellata* served as intermediate hosts. None of these species occur in the United States, and the species which actually serves as larval host is as yet unknown.

The common liver fluke is distributed over nearly the whole of Europe, and also occurs in North and South America, and Australia, where it has been introduced in domestic animals. Records of its occurrence in Africa and Asia are undoubtedly due, in part at least, to confusion with closely related species, and must be verified before they can be accepted as final.

Pathology. — Known since the middle of the sixteenth century, the common liver fluke was first positively identified as a human parasite by Pallas in 1760, although...
earlier reports of Malphighi and others probably concern this species. Between twenty and thirty well-established cases are on record; they have been compiled and discussed by Leuckart, Blanchard, and Moniez. All degrees of infection are represented, from such as were so slight as to have been discovered by accident to such as were the direct cause of death. In the bide ducts the flukes have only rarely evoked serious symptoms, though in two or three cases fatal termination was due to obstruction of the ductus hepaticus s. choledochus by oblique the parasites. In the majority of cases the parasites produced no noticeable symptoms, evidently due to the presence of only a small number of individuals, and it is possible that infection is more general than heretofore believed. At any rate Kratter proclaims it to be frequent; these cases of parasitemia Perroncito found distome eggs frequently in fecal examinations among laborers at the St. Gothard tunnel. Even in severer cases the symptoms are general, indicating only some affection of the liver. Thus pain in that organ, swelling and lacerus have been regarded as isolated symptoms of the infection. In some cases, also, the parasite has not been found in its normal seat, the liver, but as an erratic in the lungs, in blood-vessels, in subcutaneous tumors, and elsewhere. This is not to be wondered at, as demonstration that the liver fluke subsists on blood; thus young flukes especially may have found their way into the circulatory system and be carried by the blood current into any part of the body.

The occurrences of erratic individuals give some basis for the interpretation of other doubtful organisms as also belonging to this species, and many authors regard the Heterophyes varius, reported by Treutler in 1798, from the fihial vein of a young man which ruptured whilst the man was bathing, as another Fasciola hepatica. Leuckart, however, says there is more reason to regard it as a free living planarian, which did not actually come from the vein, but was obtained accidentally from the water.

Another report of Fasciola hepatica in man have been recorded locally in Europe, where the only one outside being from Australia. The record of Chabert in 1852, that this species occurred in Boston in company with Tenia, rests upon an erroneous view regarding the isolated segments of the taeniid worm. Leuckart and Cobbold have clearly shown. Nevertheless in those parts of this country where Fasciola hepatica is common, cases of human infection are likely to occur. This takes place supposedly through the consumption of eggs, the larvæ of which have been grown in low, damp regions where infected snails were present, and where consequently the liberated cercariæ had opportunity to encyst upon the leaves. The occurrence of such an occurrence coincides with the usually mild infection in man as compared with the domesticated animals.

Associated with the light infection and also with its infrequency is the absence of any definite symptoms In the human host which denote the presence of the parasite. As already explained, the infection usually becomes known only by chance, but even were it determined by accidental discovery of the eggs in fecal examinations, no special means could be suggested to bring about the eradication of the parasite, while the excretion of the eggs of the liver, and is held against retrograde movements by the thick-set, retorse spines that cover nearly the entire body. So far as can be determined the life of the adult lasts not more than about a year. Cure in the use of uncooked food discovered by accident to such cases was only a rare occurrence. Some of the cases are too poorly known to allow of exact identification. In one case four immature distomes were removed from the eye of a five months' child with lenticular cataract with partial opacity of the cornea. The other case was that of an elderly woman from whose eye eight so-called monostomes were removed from the lens substance. The descriptions do not enable one to determine the species or to assert the identity of the forms. They were undoubtedly erratic parasites, and it seems highly probable that in the former case, at least from the site was the young form of one of the liver flukes of man. Several authors regard them as very young lance flukes (Dicrocoelium lanceum) which had strayed into this unusual location. There is every ground for believing them to be the geese, as are other species of the eyes of other vertebrates (e.g., fish), and a repulsion of the occurrence on the part of the erratic young of the same or other species may be confidently predicted. (For full data on these cases compare Stiles 1862.)

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human host in Europe indicates that this species also may adopt the same rôle here when circumstances favor.

Fasciolopsis Looss.—Fasciolina without distinct anterior and posterior regions.

Cuticula smooth. Acetabulum powerfully developed with cavity extended posteriorly as saculate invagination and much larger than oral sucker. Intestinal crura swelling, slender, wavy but without evaginations. Testes dendritic, with branches growing smaller toward distal ends. Cirrus pouch very long, cylindrical, containing spiral tubular seminal vesicle with peculiar cecal appendage. Cirrus closely covered with fine spines. In alimentary canal of mammals.

Fasciolopsis Buski (Lankester 1857).—(Syn.: Distoma Buski Lankester, 1857; Distoma crassum Busk 1858, nec v. Siev. 1836). Length 24-37 mm., average about 30; breadth, 5.5-12 mm., average, 9 mm.; greatest thickness, 1.5 mm.; body (Fig. 4780) flattened, linguiform, anterior region tapering, but not sharply marked off from posterior body. Anterior sucker 0.5 mm. in diameter, acetabulum separated by not more than its diameter (1.6-2 mm.) from anterior end, with deep triangular lumen. Pharynx large, powerful; pre-pharynx present, osophagus very short; intestinal crura slender, extending to extreme posterior end in three shallow curves. Testes dendritic one behind the other in median field, and both posterior to transverse yolk duct; cirrus sac median, cylindrical, much elongated, enclosing long spiral seminal vesicle with lateral elongate cecal appendage. Germarium small, dendritic, anterior to testes, and to transverse yolk duct; Laurer's canal present, receptacularium half of body; uterine glands lateral with numerous very small acini extending length of body; genital pore immediately at anterior margin of acetabulum, cirrus covered with many fine spines; eggs numerous, 0.12-0.126 mm. in length, 0.077 mm. in breadth; similar to those of Fasciola hepatica.

Eight positive and several uncertain cases of the occurrence of this species are on record. They are all from southern or eastern Asia and all concern the human host. The parasite occurs in the duodenum according to Busk, and the symptoms of Cobbold's and Olhner's cases pointed unmistakably to this as an intestinal parasite. No facts on the life history are recorded as yet. In 1891 Leidy reported as belonging to this species specimens received from New York, Arkansas, and Texas, where they were collected from the liver of a dog in the first case and from cattle in the other two instances. The species he had under observation, however, was actually Fasciola magna, and there is no evidence that Fasciolopsis Buski has been found on this continent, although its occasional introduction by the Chinese is not a remote contingency in view of the known facts regarding other species (cf. Paragonimus Westermanii and Opisthorchis sinensis).

Fasciolopsis Rothhurisi (Poirier 1887).—(Syn.: Distoma Rothhurisi Poirier 1887.) Length 25 mm., breadth 16 mm., oval, with indistinctly marked anterior region (Fig. 7481). Cuticula smooth. Oral sucker 1.5 mm., ventral 2 mm. in diameter. Intestinal crura unbranched; germ gland dendritic, posterior to transverse yolk duct; vitellaria lateral, not joined posteriorly; uterus in centre of anterior half of body; genital pore just in front of acetabulum. Eggs 0.150 by 0.08 mm.

Nothing is known of the development of this species. It has been observed only once in a Chinese woman, who vomited the specimens after violent pain in the region of the liver. Possibly the cases reported by Blanchard from correspondence with P. Manson belong to this species.

Paragonimus Braun 1899.—Body thick, oval, or spindle-shaped, and nearly circular in section. Cuticula spinous. Acetabulum near centre of body. Alimentary canal with prominent pharynx, very short osophagus, and intestinal crura extending in irregular zigzag to posterior end. Excretory bladder large, extending nearly to pharynx. Genital pore lateral near acetabulum. Special copulatory organs wanting. Testes dendritic, right and left in posterior region. Germarium also dendritic, anterior to left testis. Receptacularium semina lacking. Laurer's canal present. Vitellaria extensive, on side of body almost the entire length and dorsal also almost to median line. Uterus scantily developed as coiled lateral to and near acetabulum. Eggs large. Usually by pairs in cysts in lungs of mammals.

Paragonimus Westermanii (Kerbert 1878).—(Syn.: Distoma Westermanii Kerbert 1878, D. Ringeri Cobbold 1880; D. pulmonale Bach 1883; D. pulmonis K. S. and Y. 1881; Mesogonimus Westermanii Baillie 1899.) Length 8-16 or even 20 mm., breadth 4-8 mm., body thick and plump, posterior end more pointed, ventral surface more flattened (Fig. 7482); color, deep red or reddish brown when alive, or dark gray in alcoholic

**Fig. 4780.—Fasciolopsis Buski (Lankester). Cs, Cirrus sac; other abbreviations as before. × 3. (After Olhner.)**
material, with conspicuous black dendritic acini of the yolk gland along the side. Cuticula spinosa; oral sucker 0.53–0.75 mm. (Leuckart), or 0.86–1.3, or even 1.4 mm. (Ward). Acetabulum 0.6–0.75 mm. (Leuckart), 0.75–1.02 mm. (Ward); slightly larger than oral sucker, situated anterior to middle of body; oesophagus, a single cava wavy, with irregular outline, extending to posterior end of body. Germanium branched, posterior to acetabulum, laterally outwards. Oesophagus coiled, the delicate shell gland, which lies directly in front of the condensed uterus. Yolk glands highly developed, extending from anterior to posterior end, absent only over narrow median field. Testes branched, lateral, in posterior portion of body; cirrus and cirrus pouch wanting generally near anterior extremity. Acetabulum, either median, right, or left; eggs oval, 0.08–0.1 by 0.05 mm. (Leuckart); 0.083–0.118 by 0.048–0.055 mm. (Ward) (Fig. 4780).

The oval ciliated embryo develops within the egg some time after the latter has been discharged with sputum from the host. Further life history unknown.

This parasite has been found in the tiger, cat, dog, and hog as well as in man. It appears from the studies of Ward and Stiles that differences in size are noticeable between the Asiatic (Fig. 4784) and American (Fig. 4782) forms. These differences are described given in further study may show them to be distinct species. The different arrangement of the sexual organs may represent the condition of sexual amplifying, noted above.

Distribution. — The parasite is known from Japan, China, Corea, and Formosa, where according to good authorities fifteen per cent. of the entire population is infected. In this country it has been reported from Michigan and Ohio by Ward, and from Kentucky and West Virginia by Stiles, according to near as accurate it seems to be common in hogs of the infected district. Thus far it has not been reported from a human host in the United States. Stiles has made an exhaustive study of this species, but is unable in spite of the recorded differences in size to differentiate the American and Asiatic forms. Even should they prove to be distinct, however, possible danger to man would not be eliminated since the Asiatic form has been found in cat, dog, and hog as well as man, and the American form, which has thus far been reported only from the cat, dog, and hog, may confidently be expected to recur in man in the infected district. Until the announcement by Stiles of the existence of an extensive infection among hogs, it was not clear that the species had actually established itself in the United States, as the two cases in cat and dog which Ward reported might have been introduced from Asia after infection. Now that a large number of cases is known from this country, the endemic character of the species cannot be doubted. Of the greatest importance that the distribution be more precisely established, and the life history worked out to show the points of danger for the infection of man and the precautions which must be taken to guard against it.

The case was first reported from man in 1880 by Manson, who called it parasitical hemoptysis and later endemic hemoptysis. The term pulmonary distomatosis has also been used. From the cases thus far on record in detail, it is apparently much more prevalent in males than in females, and seventy-five per cent. of these cases occurred among farmers. Both of these facts undoubtedly point to factors in the life history which make infection of such persons easier rather than to any inherent susceptibility. In fact Yamagiwa states that strong persons are more susceptible than weak, but this is evidently because they are more given to outdoor occupations, and hence more open to infection.

Ordinarily the worms are found in the lungs, where they lie in tumors about the roots and along the dorsal border under the pleura, sometimes surrounded by a capsule or again burrowing into the lung tissue. The worms occur in man usually one, but in other hosts two, in each cyst, although instances are not rare where one or several have been taken from a cyst, and some cysts contain more than one adult worm. The cysts contain not only the worms, but also masses of eggs, and Charcot's crystals, while cholesterol crystals are also occasionally present. The eggs and crystals reach the exterior in masses of mucus and blood through fine openings from the bronchi. The number of eggs discharged in the course of a single twenty-four hours may be enormous, and was estimated in case of one patient who had suffered thirteen years from the disease as not less than twelve thousand daily.

Yamagiwa has also found in the brain cysts containing the parasites and eggs or simply the eggs. Foci of these eggs and small blood-vessels filled with them occurred in the cortical substance of occipital and parietal lobes; and even in the brain-stem. In the spinal cord they are characterized by epileptic attacks (Jacksonian or cortical epilepsy).

Yamagiwa has also found cysts containing the eggs of this species in the liver, causing or associated with cirrhosis of that organ, as well as in the diaphragm, peritoneum, mesentery, and walls of the intestine.

Symptomatology. — When in the lungs, its common abiding place, the distome gives rise to periodic hemoptysis and chronic cough, with rusty, mucoid expectoration; splitting of blood is common but not constant. The condition of the patient remains good, and almost no abnormal sounds can be detected by percussion of the chest. Yamagiwa says that the general appearance of the expectoration is identical with tuberculosis, and that the disease was formerly diagnosed as such in Japan. The presence in the spuia of the eggs already described makes a positive diagnosis by microscopic examination easy. Accidental rupture of a large blood-vessel by the destruction of lung tissue, and in severe cases general anemia, are the dangers to be feared.

**Fig. 4783.—Egg of *Paragonimus Westermanii* (Kerb.) (After Katsurah.)**

**Fig. 4784.—Egg of *Paragonimus Westermanii* (Kerb.) (After Katsurah.)**

**Fig. 4785.—Paragonimus Westermanii (Kerb.) in Ventral Aspect. Japanese specimen from human lung. × 7. (After Katsurah.)**
Removal from an infected district is followed usually by complete recovery.

In absence of any knowledge regarding the life history the mode of infection is entirely in the dark, and equally so the means of prevention. Of general grounds drinking-water has been suspected; more suspicious are all uncooked plant foods, and especially such as are grown in moist places. In the light of present knowledge little weight can be laid upon the ideas of certain Japanese that fish, eggs, and meat are responsible for the transference of the parasite to the human host.

Opisthorchis R. Blanchard 1886.

Body flat, elongated, broad posteriorly, but tapering toward the anterior end. Cuticula without spines. Testes, lobed or even branched, located one obliquely behind the other in posterior region. Genital pore just in front of acetabulum; no special copulatory organs. Receptacle seminiferous large, Laurer's canal absent, germarium anterior to testes. Uterine coils anterior to germarium and within intestinal cura. Vitellaria lateral, never anterior to acetabulum. Excretory bladder Y-shaped, the long unpaired stem curved like an S between the testes.

**Opisthorchis felineus** (Rivolta 1885) — (Syn.: Distoma felineus Gurlt 1825; D. lanceatum, D. sibericum Winogrado& 1892; D. tenue, D. pseudofelineus Winogrado& 1896).

Body much flattened, with sides parallel save that the region anterior to the acetabulum is convex and very changeable in form when alive. Posterior end often slightly pointed. Color faint reddish-brown or yellow; when alive, transparent. Length 8-11 mm., breadth 1.5-2 mm. Suckers separated by only one-fifth to one-sixth of the length, nearly equal in size; 23-25 mm. Esophagus very short, intestinal cura reaching nearly to posterior end. Excretory bladder forking anterior to testes. Anterior testis four lobed, posterior five lobed. Germarium median, transverse, smaller than the pyriform seminal receptacle. Uterus entirely within intestinal cura. Vitellaria, in the broad lateral fields, composed of seven to eight distinctly separated groups of follicles, all anterior to ovary. Genital pore immediately preacetabular. Eggs oval with distinct lid at pointed pole. 0.030 by 0.011 mm. This much confused species has been carefully studied by Braun. It inhabits the gall ducts and gall bladder of the cat, dog, fox, glutton, and man. Of the life history little is known. The eggs when laid contain a ciliated miracidium which, according to Braun, is borne out in water, although in Winogradoff's experiments they are said to have done so. Further knowledge on the development is lacking.

**Distribution.**—Germany, France, Italy, Holland, Scandinavia, Hungary, Russia, Siberia, and if correctly reported Japan also, are the countries in which the species has been found. It is apparently most abundant on the shores of the Baltic, and the correspondence of its distribution with that of the human tapeworm, Di-bothrioccephalus latus, is worthy of note.

**Pathology.**—In 1892 Winogradoff found in post-mortem at Tomsk (Siberia) cases of what he thought to be a new human parasite. This he described as Distometum (Fig. 4785, B), but it is probably identical with the species from the cat studied by Braun (Fig. 4785, I). Fifteen cases have been reported from Siberia, Russia, and East Prussia. In Tomsk it is the most common human parasite and in East Prussia it is also rare. Although in no case was a fatal termination attributable to this parasite, yet pathological changes in the liver were noted, such as dilatation of the gall ducts with inflammation and thickening of the walls, and atrophy of hepatic tissue. In recently infected cases the liver was enlarged; in older ones, on the contrary, smaller than normal. Ascaris was noted in three cases, enterus in five. Askamany found hepatic carcinoma in both of the cases he studied closely, and noted that it occurred in the region most visited by the parasites. He was accordingly inclined to place these facts in causal relation since the changes incited by the flukes consisted in manifold, even dendritic, proliferation of the mucosa into the likewise proliferating connective tissue. In both these cases there were over a hundred parasites and the host was apparently of average size, and they were met with also in the pancreatic duct and in the intestine. In other cases on record the number of parasites found varied from a few to several hundred.

In view of the frequent confusion of this species with Diobothriocephalus latus it is possible that some records included under the latter actually concern the former species. It has been conjectured with good reason that man acquires this species, like Diobothriocephalus latus, through the consumption of uncooked fish in which the young distome is encysted, and it is striking that in all of Askamany's cases in East Prussia both these parasites occurred together. That author, however, was unsuccessful in the effort to infect experimentally with this parasite, or to discover its immature stage.

A closely related American species is one which I originally described as a variety of *O. felineus*, but now believe to be entirely distinct. This is *O. pseudofelineus* (Fig. 4785, D), which is a frequent parasite of the cat in some parts of the country, and has been found in the dog and coyote also. The intermediate host is unknown, but many facts point to a fish intermediate. The transfer to the human host might be brought about by chance, or as in the case of the closely related species of the Old World. It occurs here in much smaller numbers than in Japan, and consequently would probably be able to maintain itself in the latter host also.

A small spiny distome which Winogradoff found in man in one instance, and which he regarded as the immature form of *O. felineus*, has been tentatively identified by Braun as *Metorchis spinulosus* (Rudolph 1819). This species is a normal parasite of the cat and had probably reached the human host in the same manner as *Opisthorchis felineus*, with which it is moreover often associated in the cat. As this form is parasitic not only in the cat, dog, fox, and glutton, but also in the human, still further evidence is furnished of the transmission of this and the preceding species through fish food.

**Opisthorchis sinensis** (Cobbold 1875) — (Syn.: Distoma...
**Trematoda.**

REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

_C. sinesis_ Cobbold 1857; _D. spathula _Leuckhart 1876, nec Rudolphi 1819; _D. hepatitis_ C. s. periovum_ Baer 1888; _D. jejunum_ R. Blanchard 1886; _D. echinum_ Ijima 1886.)

Length 9-15 or even 18 mm.; breadth 2.4-4 mm.

Body translucent, slightly tinted with yellowish or greenish; form elongated, attenuated toward anterior end, bluntly pointed at posterior (Fig. 4786). Oral sucker larger than ventral and separated from it by one-fourth the curve of the gut. Cephalic or oral cone protuberant, one of the posterior end and overlapping the intestinal canal; anterior to them the prominent receptaculum seminis and then the hind gut and one lobed, in the median line. Vitellaria lateral, extending from the acetabulum to germinarian or slightly further posterior, Uterus in transverse coils between acetabulum and germinarian is wide, but within intestinal canal. Genital pore at anterior margin of acetabulum. Eggs, from faces 0.027-0.030 mm. long, and 0.015-0.015 mm. broad; exceptionally, 0.035 by 0.018 mm.; other eggs of other species 0.02 by 0.0157 mm.; micracidium developed before extrusion from uterus. Parasite in the cat, dog, and man, but _C. sinesis_ has been found in Japan, but occurs also in Corea, Formosa, Tonquin, Chima, India, and Mauritius. A single case has been reported from New York City by Biggs; the host is poor. Recently, White has found eighteen cases of infection with this parasite (Fig. 4787) in San Francisco. All were detected at necropsies, and of these sixteen were pest infected, one a patient with heart disease. White was inclined to believe that some of the cases were infected in California, though no evidence has yet been published to show that the species has actually established itself on this continent.

In Japan the population is sparsely infected; the parasite is sporadic in some regions, but in other localities in several provinces it is endemic; in some districts of the province Okayama, according to Katsurada, from fifty-six to sixty-seven per cent. of those subjected to fecal examination were infected. Of the expelled embryo alone is known. This is formed when the eggs (Fig. 4788) are passed in the feces of the host; but, according to Ijima, it does not desert the shell spontaneously, even after five months. The intermediate host is probably a mollusk, and the rice fields, which are often fertilized by human excrement, are centres of infection.

The mode of transmission can only be conjectured.

The parasite occurs either in the gall ducts and gall bladder or in the pancreatic ducts. It is present also in the duodenum and rarely in the stomach and spleen. The pathological changes are of a mechanical type, and apparently generally proportionate to the duration of the disease and to the number of worms present, which may reach ten thousand or more in a single host. In cases of severe infection the death of the patient follows; this occurs in about fourteen per cent. of the sick. Two hundred and twenty fatal cases were recorded in twelve years in the province of Okayama. Like other species, this parasite has been found outside the liver in pus of a phlegmon on the right side of the abdomen, and in a second case on the diaphragm.

Pathology.—The hepatic lesions produced by flukes were first accurately determined by Schaper for _Fasciola hepatica_ in cattle and sheep, and subsequently confirmed by Katsurada and Blanchard, both of whom studied the changes in the human liver produced by _Opisthorchis sinesis_. The results show essential similarity in all cases studied. The lesions are of two sorts; the first, due to the occlusion of the biliary ducts by the parasites, and secondly consists in congestion, bile-stasis, bile-dilatation of the ducts with resulting effects on general nutrition. At the same time the resulting inflammation leads to desquamative catarrh accompanied by thickening of the mucosa and glandular hyperplasia. There is also a puffy lobular reaction, and in the centre of the connective tissue together with increase in blood capillaries and cellular infiltration, which aids in the reduction of liver tissue and in the obliteration of bile ducts. Atrophy of the parenchyma and granular degeneration bring about the loss of the capillaries of the liver, and ultimately the transformation of a larger or smaller portion of the liver into a mass of cirrhotical tissue containing only metamorphosed gall ducts.

The effects upon the circulatory system are primarily mechanical in the injuries to capillaries producing multiple hemorrhages, and where these discharge through gall ducts resulting in anemia. The inflammation produced by the movements of the flukes affects the walls of the blood-vessels and renders it possible for the flakes to gain entrance to the systemic and then to various parts of the body. The growth of connective tissue serves ultimately to compress branches of the portal system, or even partially to obliterate them, and the condition produced by asci and acints is caused by the enlargement of the spleen, pathological changes in the pancreas, when that organ also becomes infected, and chronic gastro-intestinal catarrh have been recorded. In fluke disease among animals it has also been noted that the blood is high in hemoglobin and subnormal in number of corpuscles.

_Opisthorchis norae_ Braun 1902.—(Syn.: _Diotoma con- junctum_ Lewis and Cunningham 1872, McComnell 1878, nec Cobbold 1859.) Body lance-shaped, spinous, 9.5-12.7 mm. long by 2.5 mm. broad. Surface closely ciliate, together, the oral being larger than the ventral. Pharynx spherical, intestinal erura extending far posterior. Genital pore immediately in front of acetabulum; testes round or only slightly lobed, at limit of posterior third of body and nearly opposite. Germarium slightly lobed, in front of bifurcation of the Y-shaped excretory reservoir. Uterus in loops through central area from germarium to genital pore. Vitellaria lateral, from testes anterior nearly to acetabulum. No cirrus sac. Eggs oval, 0.094 by 0.092 mm.

Found in a necropsy in Calcutta in large numbers in the gall ducts of two Mohammedans by McComnell. Similar parasites were discovered a few years earlier by Lewis and Cunningham in the liver of street dogs in the same city. No doubt these forms were both the same species, but Braun has shown clearly that they cannot be the species which Cobbold had found earlier in the liver of an American fox that died in London, and to which the discoverers had assigned them.

_Heterophyes_ Cobbold 1886.—Body without distinct separation into anterior and posterior region. Oral sucker without crown of spines. Pharynx a little to oral sucker, intestinal erura extended to posterior end of body. Genital pore and acetabulum on same side, near acetabulum, surrounded by prominent muscular genital sucker with circle of branched chitinous spines. Vitellaria near posterior margin, scantily developed.

_Heterophyes heterophyes_ (v. Siebold 1852).—(Syn.: _Diotoma heterophyes_ v. Siebold 1852; _Mesostrongylus heterophyes_ Raulin 1890; _Cernogonius heterophyes_ Looss 1900; _Oxygastrotricha heterophyes_ Liébou 1900). Length 11-14 mm., breadth 0.3-0.4 mm. Limit between anterior mobile and posterior regions often indistinct in alcoholic material (Fig. 4789). Acetabulum very powerful, thick-walled, about
two and one-half times and genital sucker about one and one-half times as large as oral sucker; a median diameter of oral sucker 0.09 mm., of ventral sucker 0.33 mm., of genital sucker 0.15 mm. Intestinal crura thin, terminating posteriorly at excretory bladder. Lateral acini of vitellaria outside intestinal crura, sometimes even extending on to ventral surface. Testes near posterior end, just anterior to lips of intestinal crura. Germarium median in posterior region, uterus covering nearly entire posterior end. Eggs light brown, thick-shelled, 0.017 mm.; ciliated miracidium fully developed when egg is deposited (Fig. 4730).

Parasitic in dog, cat, fox (?), and man in Egypt. A single record of its presence in dogs in Japan needs confirmation. The species was discovered in 1851 by Bilharz in the intestine at the necropsy of a boy in Cairo. The belief that the species was rare in man has been dispelled by the studies of Looss, who finds it rather common; on account of its diminutive size, however, it is easily overlooked. This author has also recently differentiated some closely related species which have been found in other hosts and listed heterofo before the same name. Its seat is the middle third of the duodenum, and it is often found by the hundreds. It usually moves about freely in the chyle, but may remain attached to the wall or concealed in the folds of the mucosa. The parasite feeds on the contents of the intestine, and neither blood corpuscles nor epithelial cells could be found in its alimental canal. This accounts for its apparently harmless character even when present in large numbers. In spite of the prominent spines on the skin Looss was unable to recognize in any case alterations in the alimental canal, which could be attributed to the work or presence of the parasite. According to Looss also the parasite affects particularly the country population and is wanting in those who live in the cities as well as in Europeans.

_Dicrocaelium_ Looss.—Body delicate, semitranslucent; form elongate, foliate, tapering toward both ends, with smooth cuticula; oral and ventral suckers separated by less than one-fourth total length. Pharynx small; cesophageal short; intestinal crura long but not extending to posterior end. Cirrus sac anterior to acetabulum, enclosing coiled seminal vesicle and long slender cirrus. Genital pore between pharynx and fork of intestine. Testes compact, forming with the smaller compact germarium a median series directly posterior to acetabulum. Laurer's canal and rectum clearly present. Uterus in transverse coils, filling region posterior to germarium. Vitellaria lateral to intestinal crura, only moderately developed. Eggs dark brown, numerous.

_Dicrocaelium lanceatum_ Stiles and Hassall 1896. (Syn.: Fasciola lanceolata Rudolphi 1803, nec Schrank 1790; Diatomana lanceolata Mehlis 1825; _Dicrocaelium lanceolatum_ Looss 1913.) Length 4, usually 8-10 mm., breadth 1.5-2.3 mm. Body flattened, lanceolate, attenuated toward both extremities, especially the anterior (Fig. 4791). Suckers separated by about one-fifth total length; diameter of oral sucker about 0.5 mm., of ventral about 0.6 mm. Intestinal crura terminate one-fifth of total length from posterior end. Genital pore at intestinal fork. Testes slightly right and left of median line. Vitellaria from posterior testes through to the middle fifth or fourth of body. Loops of uterus extending laterally beyond intestinal crura. Eggs 0.028-0.045 mm. thick-shelled, dark brown. They are deposited, and containing a spherical or oval miracidium ciliated only at anterior end and supplied with rudimentary intestine and boring spine.

Parasitic in gall ducts of herbivorous and omnivorous mammals very generally, often in common with _Fasciola hepatica_. Among the hosts given are sheep, cattle, horse, ass, deer, goat, hare, rabbit, pig, and man. The records in accordance with which this species occurs in dog and cat rest on confusion with _Haplorchis felineus_.

The development of the species is unknown. Lencart found that the miracidia spontaneously desert their shells in the intestine of certain slugs (Arion, Limax), but that no further development could be induced here or in other snails. On the basis of a single feeding experiment, however, he considered small species of _Plagiorchis_ from fresh water to be the larval host. Piana conjectured that land snails were more probably responsible. No further evidence has been obtained.

The distribution of this species is less extended than that of _Fasciola hepatica_, though in general it is much the same. Lencart believed it more abundant in southern Europe than in the north. It is found in Europe in Rumania, Italy, France, and Egypt. With possibly a single exception the parasite was not the cause of any apparent trouble. In view of this absence of dangerous symptoms Braun conjectures that mild infections may be much more frequent than is known.

The family of the Schistosomidae Looss contains species of separate sexes with the male shorter and thicker than the slender female, and having a canal formed by the ventrally turned margins of the body. The acetabulum is stalked and the intestinal crura unite posterior to it. Only one genus is here important.

_Schistosoma_ Weinland 1858. Female filiform; male very broad with body rolled together ventrally to form completely closed _cinalis_ gymnophoros. Suckers near together. No pharynx. Intestinal crura in male join.
often far back. Genital pore in both sexes median, post-acetabular, no copulatory organs. Testes of five to six vesicles. Seminal vesicle small. Uterus of female very long, at times with large numbers of eggs. Eggs tapering equally to both ends with small terminal spine at posterior end, without lid. In venous system of mammals.

Schistosoma haematobium (Bilharz 1852).—(Syn.: Distoma haematobium Bilharz 1852; Gyrodahaematobium Diesing 1858; Bilharzia haematobia Cobbold 1861; Thecomastoma haematobium Moq. Taud. 1860; Bilharzia capensis Harley 1864.) Male, or usually 10–14 mm. long, 1 mm. broad, 0.14–0.17 mm. thick; female 8, or usually 13–20 mm. long, 0.28 mm. broad, 0.21–0.25 mm. thick, oral sucker 0.3 mm. in male, 0.05 mm. in female. Acetabulum pedunculate; diameter 0.38 mm. in male, 0.05 mm. in female.

**Structure.**—Through the admirable recent studies of Looss the earlier work of Leuckart and others has been confirmed and extended so that a precise account can now be given of this unique form. The two sexes must be considered separately save that both agree in the delicacy of structure consonant with their blood-current. The male (Fig. 4792) shows pupillae or warls over the entire dorsal surface, except near both ends of the body. Fine dermal spines cover the suckers both within and without. Slightly larger spines cover ventral surface of the body from the genital pore to the posterior tip, i.e., the so-called canalis gyroscopeus, as well as form a zone on the dorsal margin of that side which lies within in the formation of the canal. A pharynx is wanting and the esophagus with two expansions (A, B, Fig. 4794) covered with a layer of salivary cells terminates at or near the acetabulum, branching to form the intestinal crura. These may join soon to form the unpaired cecum, which extends in the median line nearly to the posterior end, or their junction may not occur until the posterior fifth of the body is reached; one also finds the ceca separating for short intervals in the course of the unpaired cecum. The food mass in the alimentary canal of the parasite consists chiefly of leucocytes with pigment from the liver and a few crythrocytes. The reproductive system departs widely from that of other Trematoda described in general above, first in that the sexes are separate, but secondly and equally strikingly in its structure. In the male (Fig. 4794) the testes, four or five in number, lie alternately right and left of the median line not far behind the acetabulum. As the apparent common duct is in reality a part of the organ, the group represents rather a very deeply lobed single testis. The short duct joins this to the sausage-shaped seminal vesicle, from which a short simple canal extends to the sexual pore. This pore is always located exactly at the entrance to the canal of gyroscopeus. Special copulatory organs and glandular adnexe are entirely wanting.

The body of the female is smooth except on the inner surface of the buccal capsule, where extremely fine spines are numerous and the posterior tip of the body, which carries much stronger spines, pointed in various directions. A pharynx is wanting; the esophagus with dilatations and gland cells, as in the male, divides anterior to the middle of the acetabulum, to form the intestinal crura, which unite behind the germarium to proceed as an unpaired cecum in a zigzag line, with regularly alternating lateral diverticula to the posterior end. The female reproductive system (Fig. 4793) lies largely between the acetaeae and the posterior junction of the intestinal crura. Just anterior to this junction one finds the median, elongated oval germarium. The single vitellarian with symmetrical follicles right and left of the intestinal cecum corresponds to the posterior end of the body. Its duct lies parallel to the germ duct coming from the posterior end of the germarium, and joins it at the shell gland, which is located a short distance anterior to the germ gland. After a short ootype the uterus extends nearly directly as a tube of uniform calibre in the median line to the genital pore which lies immediately behind the acetabulum.

The egg (Fig. 4795) has the form of a compressed spindle somewhat inflated at the middle. At the anterior end one finds a short irregular tip, homologous to the filament on the eggs of ectoparasitic trematodes. In those eggs which are discharged in urine this process is terminal, in such as remain in the body of the host it is slightly lateral. The egg shell contains a mature embryo, cylindrical in form with conical anterior tip, or papilla, and covered by a coating of fine chil. A rudimentary adenovagina, cephalic gland, and the usual masses of germ cells in the posterior end are easily distinguishable.

All authorities, save one, agree that the embryos do not hatch out if the eggs are left in unaltered urine, but that the addition of fresh water, especially if warm, brings about at once the opening of the shell and escape of the embryos. If left in urine the embryos die in the shell from the sixth to twenty-four hours. The further fate of these embryos is entirely unknown, as also the manner of infection. It has been conjectured that the sporocyst stage also occurred in the human host, but the experiments of Looss on apes were without result.

This species occurs as a parasite in the portal system of man, perhaps also in the Swaty monkey and in cattle.
It is widely distributed in Africa, records being at hand of its occurrence in Egypt, although at Cape of Good Hope, and at points on the western and northern shore as well as in the interior. It is very common among the Egyptian laborers, and boys and youths seem to be particularly susceptible to its attacks. One-third or more of those examined by different observers were found to harbor the parasite. The centre of infection at Mecca (Arabia) is regarded as introduced, and that recently discovered on the island of Cyprus is probably similar.

A case has just been reported by Manson in which the eggs were found in the feces but not in the urine of an Englishman in the West Indies, who had never been in any country where the parasite is known to exist. On account of its peculiar features the case needs confirmation, but if correct demonstrates the existence of a new centre of infection near our shores.

Stiles says that the human blood fluke has been found twice in this country; once in a foreigner on the "Midway" during the Columbian Exposition and once in New York City. I have found another case recorded from Georgia. All these cases were certainly infected elsewhere, and there is no evidence to show that the parasite has been able to gain a footing as yet in this country.

Pathology.—The females apparently go into the venous plexus of the pelvis to oviposit, and the eggs are carried thence by the blood current into various organs. Here they accumulate, excluding the vessels and causing various symptoms according to the organ affected. Such accumulations have not been found as yet in spleen, stomach, or pancreas. In the lungs they determine lesions which simulate those in miliary tuberculosis, and though rarely recorded as yet are believed to be common. Tumors of similar origin have been rarely met with in mesenteric gangling, on the peritoneum and in the bladder.

In the liver cirrhosis and biliary calculi are produced by their presence. More frequently one can trace them to the walls of the urinary passages or of the large intestine, and here more serious difficulties arise. Catarrh of the bladder and pain in the lumbar region ensue and are accompanied by the appearance of blood or bits of blood and pus at the close of micturition, which at first occur only occasionally but later regularly. This so-called Egyptian hematuria or bilharzian hematuria as it is called after Bilharz, the discoverer of the parasite, can be definitely diagnosed by the microscopic demonstration of the eggs in the urine. It should be noted, however, that these may be present in the urine without the least trace of blood.

The disease may continue for some time, even six to eighteen years, and eventually terminate without more extended symptoms.

Renewed or reinforced infection, however, intensifies the cystitis and often brings about urethritis as well. Frequently one finds urinary calculi, in many of which the nucleus of the calculi can be shown to consist of one or more fluke eggs. In Egypt one series of observations showed the coincidence of bilharziosis with lithiasis in eighty per cent of observed cases. In more severe cases the changes may extend to the ureters, kidneys, and colon. The urine contains larger amounts of blood and eggs, and the feces present a similar appearance. The symptoms then resemble tropical dysentery. Bilharz and Bilharz, the discoverer of this parasite, originally connected the two in a causal way. As a result of the changes outlined, nutrition suffers and finally death ensues from uremia, pyemia, pyelonephritis, or general mummification. The wall of the bladder shows under these conditions excessive thickening, together with the formation of excrecences, 1-2 cm. in diameter, filled with the eggs of the parasite; the cavity of the organ is diminished materially, and also the elasticity of its wall. Extensive excrecences are not uncommon, and in connection with the rupture of small vessels determine the characteristic hematuria yet in the urine.

The disease cannot be regarded as necessarily fatal; its severity depends in general upon the degree of infection. In cases of moderate intensity appropriate treatment of a general character effects a noteworthy amelioration, and in many cases at least the disease is self-terminating.

Antibiotics and other medications have been employed with variable results.

Infection is generally attributed to the use of impure water from pools and canals. It has been observed that those villages supplied directly from the Nile are rarely infected, while in those using filtered water the parasite is almost unknown. Looss has urged strong reasons in favor of the view that bathing affords the opportunity for the parasite to enter the body through the skin. Both the mode of infection and the subsequent course of the parasitic in reaching its location in the portal system are, however, entirely conjectural. Henry B. Ward.

Principal articles consulted.


Also numerous shorter papers by the same authors, Askamz, Cobbold, Dujarin, Folin, Leddy, Reidelt, Zannucci, White, and others.
TRENTHAM SPRING.—Campbell County, Georgia.

Post-Office.—Fairburn.
Access.—Via Atlanta and West Point Railroad to Fairburn, thence by private conveyance three miles north to spring.

For a number of years this spring had considerable local reputation. The principal ingredients of the water are as follows: Calcium carbonate, magnesium carbonate, iron carbonate, potassium carbonate, magnesium sulphate, sodium chloride, alumina, organic matter. The waters of this spring are said to be highly efficacious in the treatment of syphilis and scrofula.

James K. Crook.

TREPANNING: TREPHINING.—By common consent these terms are applied, not merely to the application of that form of circular saw known as the trepan (or diminutive trephine), but to any procedure by which a piece of bone is elevated, or is removed, in order to permit the elevation of some adjoining portion, or the exposure of the membranes or brain beneath. The operation dates back to the remotest antiquity, and seems to have been practised at various times among various peoples as a rite or ceremony. Except when performed by surgeons, it seems to have been done usually with the rudest of implements, and even the instruments used by the previous generation of surgeons were in most respects clumsy and coarse.

INDICATIONS.—
1. Simple fractures of the skull, with signs of compression.
2. Compound fractures, with depression, even without signs of compression, except over the frontal sinus, in adults.
3. Punctured and gunshot fractures, even without symptoms. (The reader is referred to the article on Head, Wounds of, in Vol. IV. of this Handook, where I have considered these indications in greater detail.)
4. Coma, with signs of compression, contusion, or laceration of soft parts, without fracture of the external table.
5. Hemorrhage. The operation is done in this case either to tie a vessel or to remove a clot. This is partially included under healing 4.
7. Tumor of the brain or meninges.
8. Bone abscess in the frontal sinus, mastoid process, etc.
9. Purulent meningitis, the object here being to wash out the suppurating cavity.

FIG. 4796.—The Operation of Trepnann in the Early Part of the Eighteenth Century. (From Holster.)

FIG. 4797.—1. A Fractured Skull after the Application of the Trephine and the Removal of the Fragments. (After Charles Bell.) A, B. The dura mater; C, the cranium; D, the dura mater exposed.
Protozoa
ings—and the other showing the schemes of declension of adjectives.

**TABLE SHOWING DECLENSSION AND GENDER OF NOUNS OCCURRING IN TITLES OF U.S. PHARMACEUTICAL MEDICINES AND IN COMMON PRESCRIPTION TERMS.**

### Nomina tive singular ending in **-a**:

| All First Declension and Feminine, except (of Greek origin) the following in **-a**: | 
|---|---|
| Physostig'mma (physostigma), | Catapla'zma (cataplaezma), 3d, n. |
| Apop'lanthera (apoplanthera), | Gargar'zma (gargarzma), 3d, n. |
| Theobroma (theobroma), 3d, n. | 

### Nomina tive Singular ending in **-us**:

| All Second Declension, Masculine, except | 
|---|---|
| Juniperus, 2d, f. | Rhus (rhus), 3d, f. ("rhus gla-

...
cell, viz., by division, which may be simple or multiple, and in varied form, either while free or in the encysted condition. Two types of division may alternate regularly or indefinitely in the life cycle of a given species, and in most such cases of the group parasitic forms have been demonstrated. These consist in general in the fusion of similar individuals (isogametes), or of dissimilar (macroc- and microgametes), or merely in the mutual exchange of nuclear matter.

The term does not apply to parasitic forms among the Protozoa, and affords conditions not found elsewhere. There are in this group not only organ parasites, as in the groups of helminths, but also such forms as must be designated tissue parasites, cell parasites, and even nuclear parasites. Different phases in the life cycle of a given group of these protozoa illustrate different modes of parasitism, as is the case with the malarial organisms, which at various epochs in the life history are successively cell parasites in the erythrocytes, organ parasites in the blood-vessels, and tissue parasites in the wall of the mosquito's midgut.

In general, however, the protozoan parasites repeat conditions already described for Metazoa. One finds the degeneration of organs superfluous under conditions of parasitic existence, the formation of organs of attachment (suckers), the fecundity already commented upon for metazoon parasita; and finally the alternation of generations and of hosts is a common feature among the Protozoa also.

An encysted condition of the entire individual or of a group of spores aids in the dispersal of the species, which are all inhabitants of a moist environment and cease activity at once on withdrawal of the water. This general habit renders it difficult to distinguish between mere commensals which find in the alimentary canal of higher forms conditions for their ordinary slime-inhabiting existence, without exerting any influence upon the host, and such as are parasites in the true sense.

A true parasite draws its nourishment from the host and often has a place in the life cycle of the same species or of a group of spores aids in the dispersal of the species, which are all inhabitants of a moist environment and cease activity at once on withdrawal of the water. This general habit renders it difficult to distinguish between mere commensals which find in the alimentary canal of higher forms conditions for their ordinary slime-inhabiting existence, without exerting any influence upon the host, and such as are parasites in the true sense.

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It is noteworthy that in many instances a protozoan infection is self-terminating, either that a type of immunity is acquired by the host, or that the reproductive cycle of the parasite reaches its limit without a change of host or alternation of generations. MacNeal and Novy have recently endeavored to determine experimentally the possibility of securing attenuated cultures of one protozoan parasite (Trypanosoma) with absolutely negative results; the last group of spores from so-called normal human cases had even more virulent than the organism at the start.

Regarding means of infection but little definite evidence is at hand. It is inferred that encysted forms furnish the ordinary means for transferring the species to a new host, and yet in many cases experiments along this line have been without results. In other cases it is now known that the transfer takes place through some biting insect, which in some cases, if not all, acts as the host for another use in the life history of the parasite, and is capable of transmitting the disease only after a period sufficient to allow of the development within its body of the specified portion of the life cycle.

In those cases in which the life history has been worked out (the means of passing the infection of the human host constitute the evident limitation to the spread of the disease caused by the parasite. The inauguration of a simple but effective prophylaxis for malaria and yellow fever ranks rightly as among the most brilliant achievements of scientific medicine. In some cases in which the life history of the parasite is unknown, the prophylaxis is necessarily vague and uncertain. It is wise to emphasize here the importance of co-operative effort on the part of trained observers, both in medicine and in zoology, to elucidate fully the problems which necessarily only await observation to make available. The single stand point.

All the varied modifications within the branch of Protozoa may be grouped into four well-defined classes which may be briefly outlined together with their major subdivisions, following in the main the classifications of Novy, Crafts, and Doflein, and noting principally those groups which contain forms found in the human body.

**Class I. Sarcodina**. Nautical or motile protozoa, characterized in the adult free condition by the formation of changeable processes of protoplasm as organs of locomotion. These pseudopodia may be lobose, digitate, reticulated, or finely radiate, and may be formed over the entire surface of the body, or only on definite portions. Reproduction takes place by simple division and by spore formation.

**Subclass 1. Rhizopoda.** Naked or shelled Sarcodina, having lobose or reticulated pseudopodia. The young may be flagellate as well as ameboid, and are produced by multiple division of the active cell or during encystment. Included among Amebae arc naked forms (Gymnamoebina) with both free and parasitic species, and also shelled forms (Thecamoebina) which may be free-living or parasitic.

**Subclass 2. Heliozoa.** Naked or shelled Sarcodina, typically spherical, with little change of form by ameboid movements. Pseudopodia fine, filiform, radiating from all parts, provided with axial filament and rarely changeable, exclusively free-feeding. These may be further classified together with their major subdivisions, following in the main the classifications of Novy, Crafts, and Doflein, and noting principally those groups which contain forms found in the human body.

**Subclass 3. Radiolaria.** Marine Sarcodina with pseudopodia like those of Heliozoa, but always provided with internal chitinous capsule which encloses the nucleus. Skeleton of acanthin or silica sometimes absent. A very large group of free-living or motile protozoa.

**Subclass 4. Mycetozoa.** Terrestrial saprophytic or parasitic forms, also known as Myxomycetes or slime moulds, and included under the fungi by some botanists. The motile ameboid or flagellate swarm spores, the plasmodia which adapt the organism to life within the living animal, and the spores of the ameboid individuals, and the holozoic mode of nutrition are characteristically animal features. On the other hand, the production of spores in sporangiia, often provided with stalks and other plant-like structures, are taken to prove the plant nature of these forms. All known parasitic forms in this group attack plants.

**Class II. Mastigophora.—Protozoa of variable form, naked or with cell membrane; they move by flagella, which vary in number from one to eight on each cell.***

**Subclass 1. Flagellata.** Small organisms with one or more flagella at anterior end, usually actively motile, but capable of encystment. Reproduction by longitudinal fission of free form or by multiple division in encysted stage. Rarely transverse fission occurs.

**Subclass 2. Dinoflagellata.** Naked or shelled forms with two flagella, one of which extends out from the body, while the other is wrapped around the animal. No parasitic forms.

* Multitrichia lacustris Czerny has many flagella, distributed over the whole body.
Protozoa.

III. Sporozoa.—Exclusively parasitic forms, in the adult condition without flagella or cilia, contractile vacuole, and opening for ingestion of solid food. Reproduction always by spore formation, usually within a firm membrane. Alternation of generations only exceptionally wanting. The young forms regularly begin the life cycle as cell parasites; other stages may be the same, or tissue or organ parasites.

Subclass 1. Telosporida.—At the end of a vegetative period the entire cell divides into sporocytes.

Order 1. Gregarinid. Vegetative stage intracellular at first, full-grown organism extracellular; fertilization isogamous, fertilized forms permanently extracellular. A large group of forms parasitic in alimentary and body cavities of invertebrates.

Order 2. Coecidiorrhina. Vegetative stage permanently intracellular; fertilization anisogamous; sexual generation permanently or temporarily extracellular. Many of the most important protozoan parasites of man fall in the limits of this group.

Subclass 2. Neosporida. Sporocytes are produced continually and at the expense of only part of the cell. In general these forms are not well known.

Order 1. Ciliopsoridia. The spores possess one or more polar capsules which contain a coiled thread like a nematoceyst, but sub-orders are: (1) Myxosporidia, parasitic in water-inhabiting vertebrates; and (2) microsporidia in certain invertebrates also. Both are not important here.

Order 2. Sarcosporida. Parasitic in muscle cells of terrestrial vertebrates, probably without polar capsule. Little known, but important.

Class IV. Infusoria.—Protozoa with motor organs in the form of cilia, whether simple or united into membranes, membranelle, or cirri; with macro- and micro-nuclei, reproduction by division and by budding, combined with an exchange of nuclear matter known as conjugation.


Subclass 2. Suctoria. Cilia only on young swimming stage. Food taken in by special sucking tubes; no cyto-

ome. No human parasites.

According to this classification the forms which have been reported from man may be arranged as given in the following list, in which, however, chiefly those species are included which are definitely accepted. Some few doubtful forms of special significance are listed here; and still others are referred to in the text under general headings.

Class Sarcodina.

Subclass Rhizopoda.

Order Amebida.


Class Mastigophora.

Subclass Flagellata.


Class Sporozoa.


Vol. VIII. 34

Eimeria hominis. Eimeria bigenina.


The relation of the Protozoa to disease is only just beginning to be investigated. At every point the student is met by the gross insufficiency of present knowledge: a host of isolated observations is on record. Some are clearly wrong, while others are indicative of important discoveries, though the presence of certain organisms during specific diseases needs confirmation, and equally their relation to the inception and progress of the malady. New methods must be worked out for the culture no less than the study of these forms, and the same sort of rigorous analysis is demanded in demonstrating their relation to disease which is generally given to bacteria. It seems altogether probable that they will play a prominent rôle in medical investigation in the near future, but in the present state of our knowledge any review of the group must necessarily be only a tentative one.

The class of Sarcodina, or sarcodine animals, is typically represented by the common free-living ameba, which has its parallel in the white blood cells. The most characteristic structural features is the ability to protrude a portion of the body substance in the form of a process or pseudopodium by which locomotion is achieved, and also the food particles are seized and engulfed. The subdivision of the class rests primarily upon the precise character of the pseudopodium.

Under the order Amebida are included such forms as possess lobose pseudopodia, and the sub-order of Gyramo-

beina embraces such of these as are without a shell. All the human parasites which fall within the Sarcodina are included in a few closely related genera of this sub-

order. While the structure is simple, and in agreement with the fact that the body is formed from that of the simple free-living form of the group, it is impossible to demonstrate that this is not the result of degeneration from more highly differentiated forms by virtue of the parasitic mode of existence. The parasitic species are most probably to be traced back to slime-inhabiting, free-living forms, a transition from which to the present parasitic existence seems most immediate and simple in physiological adjustment.

The ordinary method of reproduction is by simple division, recurring at frequent intervals and conserving the rapid multiplication of the species. This form has long been known, and is to be observed frequently in all truly independent organisms of this type. Recent inves-
tigations have disclosed another reproductive type: under definite circumstances, possibly only after fusion of indi-

viduals or some exchange of nuclear matter, the ameba forms a cyst within which the nucleus undergoes multiple division, and ultimately the protoplasm arranges itself about the new nucleus, so as to give rise to an equal number of small amebae. When these desert the cyst there is left behind a residual mass of protoplasm. At first dis-
tinguishable slightly in structure as well as size, the small ameba thus produced soon grow to the size and appearance of the adult. The occurrence of this stage in the life cycle has not yet been demonstrated for paras-

itic amebae, except very recently for Entamoeba coli and E. histolytica: but if present it may well be related to the spread of the species as found in the change of hosts. The necessity for such a stage would explain the ineffectual attempts which have been made to inoculate new
hosts by direct transference of the ordinary parasitic form.

In the genus *Amoeba* the separation of species is exceedingly difficult on account of the insignificant features available for purposes of differentiation. There are those who lump the forms found in man with such as occur in other mammals under a single species, and there are also those who contend that each host shelters a distinct parasitic species, and bring as evidence the individuality of parasitic forms in groups. In some or on the other hand it may be urged that the amebae are not highly differentiated as parasites, and mere difference in host animals has long since been abandoned as a distinguishing mark between parasites from higher classes. It is certain that no positive statement can be made until more complete information is obtained regarding the life cycle of the species. At present no one can affirm that a given species does not possess a free-living generation as well, or even that it is not a normal free-living form which under favorable circumstances has taken up the parasitic mode of life; in which case it should be regarded as a more accidental parasite. Furthermore of only one human parasite included within this group can it be said positively that it is more than a harmless commensal. Although facts have been adduced to show that others also play a pathogenic rôle, the question must still be regarded as at least an open one.

Among the ameboid bodies which one finds in nature and in culture many are only developmental stages rather than independent organisms, and the same may well be true of some of the parasitic forms. On the other hand, the distinction between such organisms and various structural elements of the human body is often a very difficult task, and some of the purported parasitic species are in fact referable to the misinterpretation of the body cells referred to above.

In the new genus *Entamoeba* are included two important human parasites, the life history of which has recently been well elucidated. The other imperfectly known species are left in the old collective genus *Amoeba*, but fuller knowledge may result in the transfer of some to this same or other new genera according to the facts ascertained regarding the life history of the individual forms.

*Fig. 5165.—"Amoeba coli." from Dysenterie Intestinale, more or less filled with Erythrocytes; Nucleus also visible. Magnified. (From Doflein after Roomer).*

*Fig. 5164.—"Amoeba coli," from Dysenterie Intestinale, more or less filled with Erythrocytes; Nucleus also visible. Magnified. (From Doflein after Roomer).*

Ecotusor not distinct save in pseudopodia, where it is conspicuous, everywhere less refractive than endoplasm. Pseudopodia rare, usually one or two, broadly lobed and heavy (Fig. 5164). Endosorae finely granular, with one or several non-contractile vacuoles, and many objects ingested as food; such are leucocytes, erythrocytes, cosinophilia, bacteria, starch granules, fascial particles, epithelial cells, etc. (Fig. 5165). The digestion of erythrocytes is accomplished without excetration of any pigment masses.

Reproduction in the human intestine by simple division and by schizogony, with the formation normally of eight daughter cells. In the nucleus the genes undergoes ameboidal division, while in schizogony complicated nuclear changes are seen with the elimination of a portion of the chromatic substance. As a preliminary step to eneystment all foreign bodies are extruded from the protoplasm, which thus becomes clear and transparent. These cysts, first discovered by Grassi, were carefully studied by Casagrandi and Barbagallo. They constitute the means of transmitting infection, as has been determined experimentally, first by Calandruccio who swallowed such encysted forms and found the developed amoebae twelve days later in the feces. The normal size of this species is the upper region of the colon, and the vegetative forms appear in the feces only when the latter are semi-fluid by reason of disease or of the administration of medicaments. The cysts which are so characteristic as to be confused with nothing in the feces are capable of further development only when they contain eight nuclei. Other cysts have been determined experimentally by Schaudinn to be incapable of development, even though they actually constitute the major part (eighty per cent.) of those evacuated. In old dry fecal matter only the forms with eight nuclei are present, and in light color of the feces, the host eight small amoebae are formed by division of the protoplasm and emerge to begin a new infection and a new vegetative period.

This species occurred in East Prussia in fifty per cent. of the cases examined; in Berlin the number found infected was 1:5, and on the Adriatic coast 2:3. The exact distribution of this species has not been further worked out, though the numerous reports lead one to believe that it is a cosmopolitan species.

Grassii was the first to identify the species from the normal human canal, and Schulberg confirmed this by a considerable series of cases. Casagrandi and Barbagallo demonstrated conclusively that it does not possess pathological characteristics, and quite recently Schaudinn in an exceedingly extensive and careful investigation showed the existence of two very similar species, hitherto generally confused, one of which, that under consideration, is a harmless commensal, and the other to be considered next a dangerous parasite. They first lives in the human host in health and is widely distributed; it multiplies excessively in various intestinal disturbances, and is brought to the exterior in fecal matter by any conditions which produce fluid or semifluid discharges from the canal. It can indeed coexist with the formerly species, which is pathological in the extreme. The present

* In advance of the appearance of Schaudinn's figures it did not seem advisable to do more than quote the name given in the original from which these cuts were taken.
The amoeba was first carefully studied by Casagrandi and Barbagallo, and is easily recognized from their account. In the majority of cases reported, however, if it is doubted as to whether or not the organism was an amoeba, it is probable that in many of them both species were studied and the description contains features characteristic of both. This is the case with the full and valuable account given in Vol. I. of the present work. (See Amoeba, Barbagallo.) In this admirable review of the subject have been added here only such features as aid in distinguishing the two recently differentiated species.


In many general features like E. coli, often occurring together with the latter, and heretofore generally confused with it, yet distinguishable by the following features: Ectoplasm well developed and present as distinct plasma zone, more highly refractive than the endoplasm, viscous, of a yellowish and glass-like appearance. Nucleus rarely visible in life, almost homogenous; little refractive, poor in chromatin, usually with a single nucleus in centre, and with very delicate nuclear membrane, if indeed any is present. Reproduction by division and budding, the latter often multiple, and both following amitotic nuclear division. Cysts with eight daughter cells never found. Staging cases are formed when the feaces grow firmer; the progress of their formation the gradual rejection of the amoebae until the entire plasma is filled with chromatin masses, and the nucleus itself degenerates and is absorbed or thrown out. The chromatin masses collect in the peripheral zone of the plasma and come to lie in ectoplasmic hillocks, which develop to free spherules on the surface of the cell. These structures measure only 0.003-0.007 mm. in diameter, and soon acquire a yellowish-brown membrane and a highly refractive semi-opaque appearance. The remainder of the amoeba goes to pieces. Schaudinn was able experimentally to produce dysentery by feeding these spores to cats, and maintains on good grounds that such spores constitute the only means of producing a new infection normally. Injections per anus of the vegetative form alone produced a typical case of the disease, as Jürgens showed first.

While E. coli has no power to penetrate the healthy epithelium, E. histolytica is able to enter anywhere and force its way through. In this process the amoeba push the cells apart, and even force them free from the layer. These cells were first correspondingly described by Ijima, who gave a full and accurate account of this species. His discoveries on the cat have been confirmed by the observations of Schaudinn on man also. The amoebae were found in sound regions of the mucosa in the glands of Ijima, and could be followed intact into the submucosa. Undermining of the mucosa and abscess formation follows in later stages of the malady. These investigations demonstrate clearly that E. histolytica is a true tissue parasite, like the Mucospoidea, and indeed the most dangerous of all Protozoa yet known, and that it is the cause of ulcerous amoebic enteritis.

Jürgens is the only author who in the opinion of Schaudinn has characterized this species in recognizable form, although the species was probably before many authors known but unrecognizable. E. histolytica is certainly described by him from the other species, E. coli, with which it was certainly associated in some cases reported.

The material from which the pathological species was obtained by Schaudinn came from a limited number of cases of tropical dysentery acquired in Egypt, China, and Siam. The real geographical distribution of the species is thus evidently but imperfectly known.

It is difficult to pass satisfactorily upon the specific character of the forms hitherto observed in the United States. This is due to the two references to which our knowledge of structure is limited, and to the fact that the obseverns of Craig (Medical News, March 16th, 1901) seem to have been made on Entamoeba coli of Schaudinn, in which the former described as "oval spots" the formation of the encysted daughter cells already well known from the work of Casagrandi e Barbagallo. The splendid monograph of Councilman and Lafleur in my opinion deals unmistakably with E. histolytica of Schaudinn. This species is very precisely and apparently agrees minutely with the characters, such as the form, appearance, and position of the nucleus, advanced by Schaudinn to separate the pathogenic E. histolytica from the harmless E. coli. The latter species will be known by Councilman and Lafleur will have to be used in preference to the later form given by Schaudinn and the species will be known as E. dysenteriae (Councilman and Lafleur 1891). Although illustrated by very inadequate figures, the pathological lesions caused by this species are described by these authors with great fulness and care, and anticipate very largely the work of Jürgens, to which Schaudinn accords such well-merited praise.

The following forms included under the generic name Amoeba are classified thus rather tentatively, as our knowledge of the life history at least is too limited to allow of greater precision. Probably some at least are related to the species just described if not identical with them.

Entamoeba invadens Ijima 1896.—Normally isolated individuals (Fig. 5166), adhering in conglomerate-like clusters only when dead or dying. Living specimens, spheroidal or ellipsoidal, having at one pole a small rounded protuberance or villous knob, which is closely set with fine pseudopodia. Diameter 0.015-0.03 mm., with a knob papilliform or hemispherical, 0.01 mm. in diameter at base, but capable of entire retraction at times, or the fine pseudopodia may be entirely withdrawn. Nucleus round, oval, or reniform, 0.008-0.015 mm. in diameter, and either to be discerned in the single cell or as one. Ectoplasm visible only in villous knob; endoplasm finely granular with one to several conspicuous non-contractile vacuoles and minute oil-like corpuscles.

This form was found by Miura and described by Ijima. It occurred in the serous fluid accumulation of peritoneal and pleural cavities in a female, twenty-six years old, who died from peritonitis and pleuritis endotheliomatosa. The amoebae were absent at first from the faces, but made their appearance two days before the patient's death. They were found in the serous fluid with hemorrhage in the intestine. Living and dead individuals were found together in the freshest serous fluid under direct microscopic examination of the liquid. Anisomericus, and various influences, and this is regarded by Ijima as evidence of the abnormal occurrence of the parasite. It has not been reported since then, and is explained by some authors on the basis that the supposed amoeba were only exudate cells. This statement is that it is the same ameba. A considerable number of so-called amoeba have been reported from various organs in man, and usually pathogenic characters have been attributed to them. They are known mostly from single records of their occurrence, and often lack both name and recognizable description. It has been suggested that they are commensals, and of secondary importance. It is equally probable that some at least are occasional or accidental parasites, and devoid of general importance in human pathology. Owing to the imperfect knowledge of structure in this group, all but the most careful descriptions are worthless for future study and comparison with other species. A few of the best accounts of these uncertain forms are noted here for reference.

Amoeba Kortušič Doflein 1901. — Diameter 0.03-0.088
mm. without distinct ectosarc and endosarc. Plasma coarsely granular, with very small nucleus (or nucleolus?), demonstrable only by staining. Movement more rapid than in Entamoeba coli. Usually only one or a few pseudopodia, long, digitate and rapid in formation. Reproduction not observed.

This species was found by Kartulis in Alexandria, where it occurred in an Arabian, in a tumor the size of an orange, on the right mandible. In the thick pus and on fragments of extracted bone the ameba occurred together with numerous bacteria. They had been feeding on blood and pus corporules. Although apparently distinct from Entamoeba coli, Doflein inclines to regard their connection as not impossible, and views as even more probable this interpretation of the ameba from an abscess in the oral cavity reported by Flexner. These were described as larger than leucocytes, with granular vacuolated plasma and a nucleus demonstrable only with some uncertainty. Although in both these cases the presence of Entamoeba coli in the host had not been shown by any antecedent dysentery or faucal examination, it has already been stated that this species may be present in the normal intestine, and its occurrence outside the canal in abscesses is abundantly demonstrated by other cases. It is less probable this form may have been Entamoeba histolytica, though the description is not distinctive, as the absence of lesions in the canal can hardly be explained if the pathogenic species was present.

Entamoeba histolytica Baedt 1888.—Diameter 0.022-0.05 mm. coarsely granular, containing one or several nuclei, excretory products, and erythrocytes. Movement slow, by formation of short pseudopodia. Encysted forms possibly occur.

Originally found in numbers in the bloody urine and vaginal mucus of a Japanese female, twenty-three years old, who shortly before her demise from tuberculosis manifested hematuria with strong cystic tenesmus. (Cf. Vol. I., p. 323, HANDBOOK.) Similar cases have been reported by many authors. In Jürgens's case chronic cystitis was associated with small mucous cysts filled with amebe; these were also present in the entire vagina. The descriptions are scanty and do not render a differentiation between these forms and Entamoeba coli and E. histolytica, either structurally or clinically. Present Pathogenic characteristics are certainly not distinctly shown, and in so far this case belongs more probably to E. coli if to either. Better knowledge of the species and more careful examination of the reports of previous observers may make it possible to refer some such cases to a definite species; but many will always remain uncertain.

Leydenia gemmipara Sternberg 1862; Amoeba dentalis Grassi 1879; Amoeba gingivalis Grassi 1849.—All these species were discovered in tartar scraped off the surface of human teeth. They have not been reported a second time, and Cella and Fiocca state specifically that they have failed to find ameboid organisms in the oral cavity. Grassi himself suggested the possibility of confusion with salivary corpuscles.

Amoeba pulmonalis Artault 1898.—In an examination of the contents of a large pulmonary cavity a small number of amebe were found among the leucocytes, which were distinguishable by firm contour, much finer and more uniform granulation, and a distinct nucleus or vacuole. In appearance like the epithelial cells found in sputum they manifested changes in form and position through the slow formation of pseudopodia. They were also more highly refractive, and resisted methylene blue or fuchsin longer than leucocytes, but when preserved they stained readily and were indistinguishable from the latter. Despite the conjectures of the discoverer their real nature remains entirely unknown.

Leydenia gemmipara. Sternberg 1862.—Irregularly spherical or polygonal in form when resting (Fig. 5107, a), surface with prominent verrucosities. Ectosarc and endosarc not distinctly limited, but pseudopodia more hyaline than the opaque body with numerous highly refractive yellowish granules. Diameter of body, 0.005-0.036 mm. Nucleus spherical, distinct in life, and in the preserved specimen regularly one-fifth the diameter of the body; movement very slow, produced by formation of a broad, hyaline lamella at the anterior margin; streams of granular endosarc extend to the margin of this lamella (Fig. 5107, b), and may even project beyond it as pointed pseudopodia. The endoplasm contains granules, crystalline bodies, interpreted as excretory, and numerous vacuoles which increase in size toward the center. A pulsating vacuole is present and contracts at intervals of about fifteen minutes. Two or more individuals frequently unite without fusion of the nuclei, and plasmoidia are formed by the union of many single individuals. Both division and gemmation occur. In the former the size of the resulting ameba may be very different, but is always proportional to the size of the nuclei (5:1). The nucleides divide directly, and the bud which originates as a protuberance from the surface of the ameba gradually works free and becomes an independent individual, which may at once undergo multiple division, giving rise to a mass of small spore-like forms (Fig. 5168).

Many years ago Lieberkühn observed in ascites fluid associated with malignant tumors peculiar cells; and similar structures were seen later by others. In 1896 Leyden and Schaudinn, on the basis of an exact investigation of these bodies in a particular case, determined them as a new parasitic rhizopod. Leyden had found them in the ascitic fluid of two patients in whom positive evidence of gastric carcinoma and of peritonitis had been furnished. The ameba appeared in numbers in fluid drawn off from the cavity, and could be kept alive in fluid preserved several days under aseptic conditions. Schaudinn studied the ameba carefully and pronounced them to be unmistakably parasitic forms. Some later critics have inclined to reject this view, and regard them as descendants of the human tissue cells or pathologic neoplasms. L. Pfeiffer especially has maintained that similar large ameboid cells ("exudate cells") occur in variola, vaccinia, varicella, herpes zoster, etc., and yet the contractile vacuole, peculiar nuclear structure, and reproductive processes of Leydenia indicate unmistakably an independent organism, as well as many other features in which it resembles various related free-living forms.
Protozoa.

Protozoa. The class of the Mastigophora includes a great variety of organisms, having in common hardly more than the possession of vibratile organs known as flagella, which by greater length, lesser number, and type of movement are easily distinguishable from cilia. The group shows relationships in many directions, and affords an almost unbroken link from true plant organisms. Here, again, as in the last class (Sarcodina) the uniformity of structure, coupled with an even smaller average size and very insufficient acquaintance with the life history, render it difficult to speak positively regarding the various organs.

1. Single, unattached, flagellate organisms.
2. The Protozoa.
3. The Protoprotozoa, Cercomonas.

Cercomonas. The species in this genus are rather uncommon. Confusion is possible both with plant organisms and with more developmental stages of other groups. The species are small and colorless; in form round or oval, with one central flagellum, which is projected ahead in locomotion. Many of the forms reported from the human body and assigned to this group are imperfectly known, often found but a single time, and in many cases probably pseudoparasites of various degrees. One or two of these forms need brief mention here. Bodonidinae.

Cercomonas hominis Davaine 1854.—Body pyriform, pointed posteriorly, with single flagellum at anterior end. Length 0.61-0.612 mm. Movement rapid, capable of attaching themselves by posterior tip. Smaller variety 0.008 mm. long.

Found in the defecates of a cholera patient, the smaller variety in typhoid defecates. Various later reports may be assigned to this species, including that of Lambi in 1857, which has often been erroneously identified as the same as the species described under the same name by this author in 1859. The latter will be discussed under its present name of Leishmania hofsudensis. Some authors have assigned the former species to Trichomonas, forgetful of the fact that it possesses but a single flagellum.

It would be hazardous to assert that all typical cercomonas thus far described from the human host fall unquestionably into the limits of a single species; yet in the absence of contradictory evidence they may for practical purposes be considered as such. These forms have been found in the alimentary canal, the bronchial system, in pleural exudate, and in an Echinococcus cyst. Eucystid forms have also been described. All investigators have not been equally careful to demonstrate the intestinal origin of such forms as were found in faces, and which may have been due to secondary contamination of the fecal material. Among numerous records only those of Councilman and Lalleur and of Dock concerning the occurrence of such forms in this country need be mentioned.

Momos pyrophila R. Blanchard 1895. (Syn.: M. pyrophila Neuve-Lemaire 1902.) Form similar to large spermatozoan. 0.05-0.06 mm. in diameter, of body, with long filament from anterior pole, resembling a flagellum, yet capable of retraction when the form becomes nearly spherical. Outside a cuticular (?) layer, which extends through the body in partitions, dividing it into three regions. Movement rapid, accompanied by change of form.

The Trypanosomidae are parasitic forms with a chief flagellum directed anteriorly, usually two-edged, with more or less of a spiral twist in the body, and with one edge of the body provided with an undulating membrane. The numerous species are hematozoa in vertebrates, though some live in the body cavity and alimentary canal of both vertebrates and invertebrates. Those forms of importance here fall all within the genus Trypanosoma. Much difference of opinion prevails as to the number of species and their limits. Most of them are very poorly known, although several so-called species were discovered as much as sixty years ago; indeed, no form is as yet a perfectly complete account of the life history at hand. Various species are recognized in various parts of the world as the cause of specific diseases among domesticated animals, which have assumed economic importance of the first rank. The most prominent of these are the following, together with the range and host of each species listed.

Trypanosoma lewisi, in rats and (?) the hamster, reported from Europe, Asia, Africa, and North America, and causing at times fatal epidemics.

Trypanosoma brevis, in cattle, horses, mules, and wild animals, gives rise to the myelitis or Trypano-myelitis of cattle. Its occurrence in Africa south of the Sahara.

Trypanosoma equiperdium, in horse, ass, and other domesticated species by inoculation, causes dolomia in the Scleron-Hellenic region.

Trypanosoma vivax, in horses, causing mal de caderas in South America.

Trypanosoma evansi, in cattle, producing the goldech in South Africa.

Although but little evidence is at hand, the weight of opinion is against any possibility of the transmission of these species to man.

Some structural features of the genus Trypanosoma s. str. need brief mention. The lancet-shaped body (Fig. 5169, a) shows a finely granular endoplasm and a distinct though very delicate hyaline ectoplasmic layer. The single flagellum arises near the posterior end in connection with the highly refractile granule variously dem}-

Fig. 5169.—Trypanosoma lewisi. a. Adults with erythrocyte, stained preparation. × 1,000. b. Multiplication rosette, less highly magnified. (After Francia.)
in the blood of an Englishman in government employ on the Gambia River. The case was under observation some time, namely, until the patient died in January, 1908, and manifested the following clinical features: general weakness, irregular lapsing fever lasting one to four days with apyrexial periods of two to five days, some oedema, injection of the skin, enlargement of the spleen, constant frequent pulse, and hurried breathing. These symptoms were associated with no definite organic lesions.

In many prepared slides and fresh blood mounts there were found no malarial organisms. However, in two cases of trypanosomes present varied from one to fifteen, but in apyrexial periods none were detected in the blood. The parasite usually progressed with the flagellum in front, but occasionally reversed direction for a short distance. In sleeping sickness of domestic hen in the flagellum and are communicated to the undulating membrane, in rapid motion the body rotates on its longitudinal axis so that the undulating membrane appears as if spirally arranged. In one instance a mononuclear leucocyte was observed which had paroxysm, only the flagellum and a small part of the anterior end of the body remaining free.

In films of blood taken from a child three years old the parasite was discovered again and associated with it mononuclear leucocytes. As a matter of fact, the fifth cases of the trypanosome have been identified by Dutton, Manson, and others, making in all six cases on the Congo River and seven on the Gambia, which are nearly equally divided between natives and Europeans.

It is thus evidently not rare in tropical Africa, as Dutton found his seven cases in somewhat more than a thousand examinations in Senegambia. Two investigators seem to have identified it in India also, and it may be expected to occur in other countries as well, as do the corresponding affections of domestic animals.

A final most recent contribution of great importance to this subject has been made by Castellani, who found *Trypanosoma* in the cerebro-spinal fluid of natives afflicted with the so-called "sleeping sickness." This has been exceedingly rare, disease, epidemic in certain regions of Africa, attacks only natives, and is characterized by a drowsy condition culminating in deep coma, with an all but universally lethal outcome in from three to twelve months. Hyperparasite of the anopheline species is the only known pathologic feature, and recent investigations have remained without result, and the theory of Manson that the cause of the malady lay in the presence of Fasciola hepatica has already been referred to in another article (Nematoda). Castellani's hypothesis has been greatly strengthened by the communication of Bruce to the Royal Society that *Trypanosoma* was present in the cerebro-spinal fluid in every one of thirty-eight cases of sleeping sickness investigated in Uganda, and occurred also in the blood in twelve out of thirteen cases cited on this point.

This species, which has been named *Trypanosoma Castellani* (see Sambon in Journal of Tropical Medicine, July 1st, 1908), closely resembles *Trypanosoma Brucei*, but it is somewhat different in size and other peculiarities: a more or less rounded anterior extremity (posterior extremity of most authors, but this species moves with the more rounded extremity foremost), the centrosome outside the vacuole and much closer to the posteriority, the larger vacuole placed behind (?) the centrosome, the longer free portion of the flagellum and fewer granules at the posterior extremity.

The transference of the parasite is probably due to some blood-sucking insect, as has been demonstrated for other species of *Trypanosoma*; and in the case of the sleeping sickness, *Glossina morsitans*, the Tsetse fly has been declared responsible by Brumpt. In an illuminating discussion of the subject he shows that the disease is ex-

**Fig. 571.** *Trypanosoma gambiense* with erythrocytes, drawn from stained preparation. X about 1,600. (After Dutton.)

**Fig. 570.** *Trypanosoma Levisi*. Auto-agglutination. Highly magnified. (After Francis.)

*Trypanosoma gambiense* Dutton, 1902. (Syn.: T. hominis 1903; T. Neopen Sambon 1908.) Length in stained preparation (Fig. 571), including flagellum 0.018-0.025 mm., width 0.002-0.0032 mm. Free flagellum of at least one-fifth of total length. Anterior end attenuated along flagellum, posterior end roughly conical, very blunt. Oval micronucleus just anterior to centre of body, occupying entire width of animal. Near posterior end dark spot, the micronucleus (the centrosome of Laveran and Mesnil), and just anterior to it a large vacuole well marked. The flagellum ends at the upper edge of this vacuole. The first record of the occurrence of a trypanosome in man is said to have been published by Nepveu in 1891, and again in 1898. The description given, however, is too scanty to admit of any opinion regarding its general character, though many are inclined to interpret it as a member of the genus *Trypanosoma*. This species was discovered in 1901 by Dutton in the
Protozoa.

**Trypanosoma.**

The term *Trypanosoma* refers to a genus of protozoa that are known for their role as parasites affecting animals and humans. 

**Trypanosoma brucei.**

This species is widely distributed in Africa and is associated with diseases such as African sleeping sickness. It is transmitted by the bite of the tsetse fly, which plays a crucial role in its spread.

**Trypanosoma cruzi.**

Found primarily in South America, *T. cruzi* is linked to Chagas disease, affecting millions of people across the continent. The parasite is transmitted through the feces of infected insects that bite humans.

**Trypanosoma gambiense.**

Common in West and Central Africa, *T. gambiense* is responsible for African trypanosomiasis, or sleeping sickness, which can lead to severe neurological damage.

**Trypanosoma lewisi.**

This species is found in the blood of various mammals, including humans and monkeys, and is transmitted by tsetse flies. It is associated with trypanosomiasis in Africa.

**Trypanosoma rangeli.**

This parasite is closely related to *T. cruzi* and is found in South America, where it can cause trypanosomiasis. It is transmitted by the bite of the reduviid bug, or kissing bug, which is a vector for the disease.

**Trypanosoma evansi.**

Also found in South America, *T. evansi* is known for causing evanstoxploration, which is a type of trypanosomiasis. It is transmitted by tsetse flies and can affect livestock, posing a significant threat to local economies.

**Trypanosoma congoense.**

This species is found in the Congo Basin and is associated with congo trypanosomiasis, which can cause severe neurological symptoms and can be fatal.

**Trypanosoma rhodesiense.**

This parasite is responsible for Rhodesian sleeping sickness, primarily found in parts of Africa, and can lead to severe neurological complications.

**Trypanosoma brucei rhodesiense.**

This species is responsible for the disease known as East African sleeping sickness and is transmitted by the tsetse fly. It is one of the most deadly forms of trypanosomiasis.

**Trypanosoma brucei gambiense.**

This species is responsible for West African sleeping sickness and is transmitted by the tsetse fly. It is one of the most common forms of trypanosomiasis in Africa.

**Trypanosoma cruzi.**

This species is responsible for Chagas disease and is transmitted by the reduviid bug, or kissing bug. It affects millions of people in South America and can cause severe health issues.

**Trypanosoma evansi.**

Found in South America, this species is responsible for evanstoxploration and can affect livestock, leading to economic losses.

**Trypanosoma congoense.**

This species is found in the Congo Basin and is associated with congo trypanosomiasis.

**Trypanosoma rhodesiense.**

Responsible for Rhodesian sleeping sickness, this species is found in parts of Africa and can be fatal if left untreated.

**Trypanosoma brucei rhodesiense.**

This species is responsible for East African sleeping sickness and is one of the most deadly forms of trypanosomiasis.

**Trypanosoma cruzi.**

This species is responsible for Chagas disease and affects millions in South America.

**Trypanosoma congoense.**

Found in the Congo Basin, this species is associated with congo trypanosomiasis.

**Trypanosoma rhodesiense.**

Responsible for Rhodesian sleeping sickness, this species is found in parts of Africa and can be highly fatal.

**Trypanosoma brucei rhodesiense.**

This species is responsible for East African sleeping sickness and is one of the deadliest forms of trypanosomiasis.

**Trypanosoma cruzi.**

Found in South America, this species is responsible for Chagas disease and affects millions of people there.

**Trypanosoma congoense.**

This species is found in the Congo Basin and is associated with congo trypanosomiasis.

**Trypanosoma rhodesiense.**

Responsible for Rhodesian sleeping sickness, this species is found in parts of Africa and can be highly fatal if left untreated.

**Trypanosoma brucei rhodesiense.**

This species is responsible for East African sleeping sickness and is one of the deadliest forms of trypanosomiasis.
quale observed groups of individuals which may have arisen by division. Before copulation this species loses its flagella and creeps about with bluntly lobose pseudopodia. This species is often called as the Cercamo-
nonas hominis of Davaine (1854) and the C. intestinalis of Lambi (1875), but recent studies have demonstrated the individuality of this from the two cited. There also is a tendency at present to reduce this form to Tr. coci-
data, with which it agrees closely, and only an exact study can decide the question. In the uncertainty I re-
gard it as more practical to retain both species, though they are at least closely related.

Tr. intestinalis parasitizes in the anterior and middle regions of the human alimentary canal, and has been re-
peatedly found in various parts of the world. It occurs also in the oral cavity in decaying teeth, where it nour-
ishes itself on micrococci. It has been reported also fre-
quently from diseased conditions associated with dia-
rrhea, such as typhoid, cholera, intestinal catarrh, gastric carcinoma, and once in pulmonary gangrene. The spe-
cies lives only in fluids of an alkaline reaction. Its oc-
currence in the dejecta of healthy adults has been taken to indicate a commensal relation with the parasitic Grasi, but it at least multiplies rapidly in connection with mor-
bid processes, and this may exercise an important in-
fluence on the progress of the disease. An etiological
significance cannot, in the present state of knowledge, be attributed to its presence in decaying teeth, yet there have been reports that an infection is apparently produced by drink-
ning-water and followed by diarrhoea in children. Experi-
mental infection of animals has not yet succeeded, and the presence of this species in the oral cavity, both in health and in disease, points to a possible transport of un-
known encysted forms by the air.

Some accounts referred to supposable new species more probably concern this. Such are the forms described by Steinberg from the oral cavity as Tr. elongata, Tr. can-
data, Tr. flagellata, as well as pseudolamblia, Tr. bi-
flagellata, together with the Tr. pulmonalis of Schmidt and Aartault from sputa or contents of a pulmonary cyst.

The family Polymastigidae contains small bacillal or bilaterally forms with two or three flagella on either side near the anterior end, while the posterior end is lobed or provided with two further flagella. Only one genus con-
tains human parasites.

Lambia duodenalis (Davaine 1875; —Syn.: Cercamonas in-
testinalis Lambi 1859, nec 1875 nec Perty 1852; Hexamo-
itus duodenalis Davaine 1875; Dimorphus maris Grassi 1879; Mortiera intestinalis Grassi 1881; M. intes-
nalis R. Blanchard 1886; Lambia intestinalis R.B. 1888; L. duodenalis Stiles 1912).

Length 0.01-0.016 or 0.021 mm.; maximum breadth 0.005-
0.007 or even 0.012 mm., with eight flagella nearly equal in
length (0.006-0.014 mm.). In form bilaterally symmetrical
(Fig. 5174). In ventral aspect it is rounded anteriorly and
prolonged posteriorly into a very mobile steering tail
flattened in the frontal plane. A shallow coridiform ex-
cavation of the ventral surface near the anterior end cor-
responds to the peristome and serves as an organ of at-
tachment; its margin is raised and contractile, but is
interrupted posteriorly; all flagella point posteriori;
the anterior pair follow the margin half-way around
so it seems leaving the body; the lateral pair originate near
the anterior margin in the peristome, but are bound to
the body until they come to project beyond the contour
of the animal; the median pair originate in the notch of
the peristome margin and are short and vibratile through
their entire length, being the chief organs of li-

cation; the caudal pair are inserted at the tip of the body.
The dumbbell-shaped nucleus lies dorsal to the peri-


tome. Contractile vacuole and cystosome are wanting.

Division has not been observed; the encysted form is
a single cell and is orbiculate or pseudocopulate, 5.0
in length by 0.007 mm. in breadth. Schaudinn re-
ports that copulation has been observed and is followed
by encystment.

This species was first reported by Lamb from the de-
jecta of children in Prague. It has been reported from
Germany, Italy, Russia, Sweden, Egypt, and the United
States from the human host in which it seems to be a fre-
frequent parasite. It also occurs in rat, mouse, dog, cat,
rabbit, sheep, and certain wild species, and is undoubt-
edly the common and widely distributed parasitic form.

Its normal seat is the duodenum or jejunum, rarely
other parts of the canal, where it sits with the peristome
applied to the curved outer face of an epithelial cell (Fig.
5175) on the villi. Although often in such numbers that
apparently every cell is occupied, yet no pathological
effect has been demonstrated to be exercised by these
parasites. Normally only cysts occur in the colon and
feaces, but in diarrheic conditions the free living forms
are often loose and reach the exterior.

Grassi determined by experimental auto-infection that
the cysts are the means of infection, and was unable to
detect in himself any symptoms incident to the parasitism
of the species. It is probable that cereals, or prepared
foodstuffs, are the chief source of infection. This
leads to the suspicion of a connection with the food
system of man.

The class Sporozoa embraces a series of groups of Pro-
zoa of a consistent parasitic habit, which have in com-
mon the production at some point in their life cycle of
numerous descendants, which are usually covered by
a firm shell and accordingly denominated "spores." The
enclosed young forms may be single or manifold, and in
special cases the cyst wall may be lacking. These young
forms always start the life cycle as cell parasites, and in
all but rare cases alternation of generations appears in
the course of the life history. All forms are true para-
sites, and all subsist only on fluid nourishment obtained
by means of a mouth.

The class was made by Leuckart in 1879, when he
brought together under the heading Sporozoa the imper-
fectly known and somewhat isolated groups of gregarines
(Gregarinida), the psorosperm sacs of Müller (Myxospo-
rida), the oval or spherical psorosperm of Elmer (coc-
cidida), and Rainey's or Messiher's corpuscles (Sarcospo-
rida). Later investigators have added the Microsporida,
Amongosporida, and Hamnosporida, and have been able
to fill up the gaps in the knowledge of the older groups,
so that the association of these forms stands on a much
more clear and firmer basis. This is especially true by virtue
of the recent discoveries concerning the life cycles of va-
rious forms which have revealed an entirely unsuspected complexity and interrelation of the development with the parasitic habit.

In the majority of cases two types of reproduction alternate in the life history of the organism, and this alternation is associated with different factors in the biology of the parasite. The first type subserves the rapid multiplication of the parasite within the host, and is appropriately designated by Doflein multiplicative reproduction; when highly developed it will evidently transform an organism harmless because insignificant into an abundant destroyer of tissue and the exacter of disease. This may be observed again and again in the history of this group. The other type of reproduction is connected with the spread of the species, the infection of new hosts, and may be denoted after Doflein the propagative reproduction. Spore formation is here associated with all sorts of secondary or collateral structures which assist in the transport of the spores, their protection during this period, and their attainment of the new host. The morphology of the propagative reproduction constitutes the means of characterizing the major sub-divisions of the Sporozoa; the multiplicative reproduction varies often widely among closely related forms.

The two sub-classes, Telosporidia and Neoportesporidia, are distinguished by the fact that the former produces spores only at the close of the vegetative period, while the latter do so during the entire period. For the identification of sexual reproduction a rudiment of the vegetative stage is rarely sufficient, the form and number of the spores produced during the propagative period of reproduction are characteristic.

In the sub-class Telosporidia one may distinguish two orders on the basis of the habit of the parasites and the mode of reproduction which produces the Coecididormoph the vegetative stage is permanently intra-cellular, while the sexual generation may be so only transiently. The fertilization is anisogamous, i.e., the fusion of differently formed gametes. In the Gregarinida in hand, the vegetative stage is intracellular only at the start, as the adult organism is extracellular and the sexual generation also. The fertilization is isogamous, i.e., the fusion of equal and similar gametes. Under the order of the Coecididormoph are included forms which until recently have been treated as much more distinct. But more careful study, particularly of the life history, has shown an increasing degree of likeness until they are now included in the same order, and mutually opposed to the Gregarinida in the specific cell process. In the sub-order of general division of the Coecididormoph in addition to the features pointed out in the outline of the system given above, the features which serve to distinguish the two sub-orders of the Coecididormoph are these: The Coecidia produce sporozoites encased in sporocysts which encase the exconjugate. The sporocyst is non-motile and remains in the cell. In the Hemosporidia the sporozoites are always free, the copula is an active ookinet, and migrates to a new location before undergoing further development.

The adult Cecidia occur as parasites in epithelial cells, particularly of the alimentary canal and its adnexa, though the excretory organs, the male sexual organs, and most recently the spleen are also reported as affected. While the protoplasm of the host cell is ordinarily the seat of the parasite, there are exceptions, such as occur in the nucleus itself. Only rarely is more than one single parasite found in an epithelial cell.

In form the Cecidia are uniform and constant, being spherical, oval, or elliptical, and without organs of locomotion of any sort or organs of attachment. Their size is regularly insignificant. A noteworthy characteristic is the absence of differentiation into ectoplasm and endoplasm. The plasma of the cell is finely granular, alveolar, and without reserve bodies or food vacuoles. The nucleus is large, vesicular, and characterized by a single prominent central nucleolus. No contractile vacuole is present, and no further structural differentiations can be noted. The cell and nucleus increase gradually in size at the expense of the host cell, which ultimately in most cases degenerates to a mere empty membrane encircling the coccidium.

The nucleus of the now full-grown parasite undergoes multiplicative division, the protoplasm stretches out in individual masses about the many daughter nuclei, and there results a stage in which a rosette of young forms (Fig. 5176) encircles a central portion of protoplasm, known as the reliquary body or residual mass. This is without nuclear matter and destined to play no further part. It is left behind, and perishes when the young forms wander out to infect new epithelial cells of the same host, and repeat the process just sketched. This is evidently the multiplicative reproduction already referred to. It serves to effect the auto-infection of the host, and is generally known as the period of asexual reproduction or schizogony. The cell parasites which undergo these changes are schizonts, while the young forms are denominated merozoites. The merozoites are capable of active movements by contraction and twistings, or with a gliding movement, in which a trail of mucus is left behind. The growth of merozoites to schizonts in the epithelial cells, the production of new merozoites, and the infection of new cells proceed often with considerable rapidity, but only within certain limits, for a new type of reproduction intervenes. In this which regularly begins under the pressure of excessive infection of the host, the merozoites develop not to schizonts, but to forms of two sorts, which at first sight are very similar to schizonts, but but little different from each other. The one form is opaque with a richly granular plasma; the other has a clear but dense plasma. The opaque form is the microgamete, or the spore formed of two cells, the macrogamete, and attains maturity by the rejection of a portion of its nuclear substance. The clear cell, known as a microgametocyte, undergoes multiple nuclear division. The number of nuclei produced then migrate to the surface, each collects a small part of the plasma about itself, and projects as an elongated spindle-shaped structure, the microgamete or male cell, which becomes free, forms two flagella, and enters upon active locomotion. The major portion of the microgametocyte is aban doned, and subserves no further function.

The microgamete swarms about the macrogametes, and as soon as one has succeeded in entering, the macrog amet forms at once a firm membrane, which forbids entrance to other microgametes. The two nuclei unite and the act of fertilization is completed. The product is a zygote in a sporont, which undergoes sporogony, and forms the starting-point of a new period in the life cycle, which is that previously designated as the propagative reproduction. It is also known as the sexual spore-forming period, or sporogony, and in most coccidia takes place...
Protozoa.

REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

They c., after Isospora. E. 3 c., Pfeifferella Sporoblast Simple E. Oocyst cuniculi | by of pletes nuclear Protozoa. though, difficulty mon Liihe genre ( = ) 538, 538 residual sporocyst (c), has been opened. All the name Eimeria, have been generally adopted. The adjointed table gives a review of the common genera arranged according to Léger’s scheme.

This general plan of development is modified in the individual species in various manner. The most striking modification is a simplification by suppression of the entire schizogenic cycle, so that the macrogametocytes and microgametocytes arise directly from the sporozoites which have penetrated epithelial cells.

The coccidia parasitize almost all groups of the animal kingdom, and are distributed over the entire world, although, as might be expected, the majority of reports thus far made concerning their presence come from European countries.

For the subdivision of the group Léger’s proposal to use the number and form of the sporozoites and of the sporocysts has generally adopted. The adjointed table gives a review of the common genera arranged according to Léger’s scheme.

Some confusion has prevailed regarding the correct names of the various genera. The original cause of this difficulty rests on the fact that the two phases of the life cycle, schizogenic and sporogenic, were discovered and named separately, and that their relations as parts of the development of a single species did not become known until a much later date. All of the human parasites thus far recorded from this group fall within the limits of a genus named Coecidium by H. Leuckart in 1879, and this name has been generally incorporated into works on the subject. At a very recent date, however, Stiles and Lühe have independently called attention to the fact that the name Eimeria, introduced in 1875 by Almá Schneidier, has the right of priority, and must replace the more common form according to laws of zoological nomenclature. This is really fortunate from the general standpoint since the name coccidia has been very generally used for the entire group as well as heretofore for the genus, yet this is not in the interest of precision, and may evidently lead to serious misunderstanding. Henceforth the name coccidia can be used only in the more general sense.

The genus Eimeria is the best known of all. Its most important characteristic is the formation in each oocyst of four sporocysts, each with two sporozoites. A residual mass of protoplasm is always present in the sporocyst with the sporozoites, and a similar residual mass is sometimes formed in the oocyst with the growth of the sporoblasts. Of the many species assigned to this genus, the most important and better known forms which are pathologic to man and some domestic animals are included in the following key:

1. Oocyst with residual mass. ................. 2
2. Oocyst spherical, 15-32 μ by 11-17 μ; sporocyst oval (mouse) ....... E. falciformis (Schuberg)
3. Simple forms. Oocyst oval to cylindrical, 24-35 μ by 15-20 μ; E. bovis (Riv.)
4. Twin forms. .......... E. bigemina (Stiles)
5. Three sporozoites. .......... Eimeria Stieda (Lindemann 1863; (Syn.: Monocystis Stieda Lindemann 1865; Proceropera cyaniculic Rivolta 1878; Coecidium oviforme Leuckart 1879; C. cyaniculic Rutil; Praetia priono Labbé 1896; Praetia priono Labbé 1890.)

All stages are known. Oocyst (Fig. 5178) in the liver of rabbit, oval 0.033-0.049 mm. long, 0.015-0.029 mm. broad. Cyst wall heavy, smooth, with opening at one pole. The coarsely granular protoplasm completely fills the cyst, but later contracts to a spherical mass at the centre (0.017 mm. in diameter). Spore formation outside the host requires two to three weeks. The entire sphere divides into four sporocysts each with a thick covering and with a length of 0.12 to 0.015 mm. and a breadth of 0.007 mm. Two comma-shaped sporozoites are formed in each sporocyst, and a granular residual mass of protoplasm lies in the hollow between their enlarged ends (Fig. 5179). The sporozoites are set free by gastric digestion. They ascend the gall ducts, pene-

Fig. 5177—Eimeria Stieda. Sporogony from liver of rabbit. a. Young oocyst; b, same with protoplasm contracted preparatory to division; c, same divided into four sporocysts, each containing two sporozoites which have already developed. Magnified. (a, b, after Leuckart; c, after Simond.)
trate the epithelial cells, and when fully grown measure 0.02-0.05 mm. in length by 0.08-0.09 mm. breadth. They divide into from 30 to 200 merozoites (Fig. 5176) which spread the infection. Ultimately the formation of macro- and microgametes leads to the fertilized sporont stage, the oocyst.

This species is an abundant parasite of the rabbit. In which it.parasitizes the epithelium of gall ducts and liver. According to the degree of infection sooner or later inflammation and charac-
terization of the epithelium lead to the formation of nodules of caseous matter, containing amid various remnants coccidia in all stages of development. These conditions may lead to severe sickness or even to the death of the host; in other cases the animal recovers as the process of schizogony appears to have distinct self-limitations. The infection is spread by the contamination of food with spor-in-
icted faces.

Several cases of human infection are on record. Evi
dently conditions favor such infection only rarely. To

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**Protozoan.**

**Eimeria:**

*Sporocysts.* The sporocysts are numerous, the epithelium of the intestine filled with coccidia, and even in large part destroyed by them. These are probably refer-
able to this species. Other authors have reported the discovery of coccidia in human faces at various times without furnishing data for the determination of the species concerned.

**Eimeria bigemina** (Stiles 1891).—(Syn.: *Cotyosprium villorum* leseartum *Cowell* *Evilov* 1874; *Cocci
dium bigeminnm* Stiles 1891.)

Oocyst (Fig. 5180) 0.012-0.015 mm. by 0.007-0.01 mm. (in dog), or 0.008-0.01 mm. by 0.007-0.009 mm. (in cat), or 0.008-0.012 by 0.004-0.008 mm. (in polecat). The oocyst divides into two parts, each of which encysts and forms four sporocysts. The oocysts occur not in the epithelium, but in the central tissue of intestinal villi (Fig. 5181).

The species was first seen as early as 1854 by Fink, who, however, misinterpreted the character of the objects. It has often been confused with *E. hominis,* from which the above characteristics easily distinguish it. A case of human infection, published by Virchow in 1860, and another by Grunow in 1891, very probably belong here. The description given by Raliliet and Lucet of coccidia discovered in the faces of a mother and child who long suffered from chronic diarrhoea corresponds well with this species in the small size of the bodies found, and is also probably referable to it. This evidently only an occasional parasite of man, and infec-
tion probably results from lack of cleanliness or too inti-
mate association with pet dogs or cats. It may be that the forms discussed as varieties from different hosts actually represent different species. Stiles has found this species in dogs killed in Washington, D. C.

It is not surprising in view of the imperfect acquaint-
ance with this group that all sorts of questionable struc-
tures should be referred to it. They are all such as have been reported from man usually in connection with some abnormal condition, and frequently also on the basis of a single occurrence. In most cases only scanty data are given concerning the supposed coccidia, and even of the best known of these problematical structures too little can be said to determine their true nature and the zoological scheme. It is best to call attention to certain of these cases briefly, in order that if possible further data should be accumulated to elucidate their real character. Perhaps the most sporozoite-like of all are those described by Rixford and Gilchrist from two cases studied at the Johns Hopkins Hospital in 1897; their characters so far as known do not permit of their classification in the coccidia (s. str.).

**Coccidinidae.Itinis** Rixford and Gilchrist 1897.—(Syn.: *C. progensis* Rixford and Gilchrist 1897.)

Unicellular spherical bodies from 0.007 to 0.033 mm. in diameter. *So-called* capsule thick, doubly contour, enclosing a finely granu-
lar substance with thin wall [ectosporium?], 0.002-0.005 mm. wide, between capsule [pellicle?] and contents. No vacuoles seen; nucleus not demonstrated. Position of parasites usually intracellular, sometimes, however, extracellular. Sporozoites [merozoites?] ap-

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*The authors give the size of the admixture (p. 239) as 15 to 37; again in the diagnosis (p. 243) as 16 to 37, and finally in their summary (p. 250) as 20 to 37. In the second case the parasites are given as 28 to 35 in diameter.*
about ten years. It was only very slightly contagious, if at all, as beyond the original sores new lesions appeared only in two spots on the patient's body, and none of those who came in contact with him are known to have become infected. Some inoculation experiments were successful, but no cultures. The cutaneous lesions resembled tuberculosis cutis in character, being the seat of genuine caseation or coagulative necrosis. Both to the naked eye and microscopically the nodules were indistinguishable from tubercles save that they contained the protozoa and did not contain tubercle bacilli. In the opinion of the discoverers this seems to indicate the power to produce toxic products which possess pyrogenic properties, causing both the local lesions and general symptoms. From the fact that the whole alimentary canal and mesenteric glands remained normal throughout the course of the disease, the authors exclude the supposition that the parasites entered the system through the digestive tract. The parasites were particularly abundant in the cascaous foci, and occurred in far greater numbers in the lesions of the internal organs than in the cutaneous lesions. Often these parasites were found in multitudes in giant cells. They were searched for in vain only in the membranes and substance of the brain.

Another case was reported by the same authors, and like the first occurred in a native of the Azores, who had been resident in California for a number of years. The disease was acute rather than chronic as in the first; and was very destructive as the patient lost both eyes, the nose, and much of the lip, and one ear in the course of three months. According to the authors the parasite was a different species, but the distinctions are insufficient to warrant a separation of the two in our present state of knowledge. The authors identify with their cases a third, reported by Wernicke in 1892 from Buenos Ayres. Wernicke gave details of the spore formation of the parasite, and regarded the cutaneous affection as a mycosis fungoides. The protozoa he found measured from 7 to 30 μ in diameter.

There are other reports of less definiteness than those just considered, and some of the questionable structures noted theretoe have found an explanation within recent times. Thus the psorospermysts of Lubarsch andRibbert, which were supposed to play a part in diseases of the urinary passages, are in reality metamorphosed nests of epithelial cells normally found in the bladder; the structures found by Künster and Pitrès in pleural exudate and interpreted by Blanchard as a sporozoan, Eimeria hominis R. Blanchard 1895, I have preferred to interpret as Echinophychnus eggs (cf. Nematidae, page 258). More uncertain still are Santé's "megalocystic aegargines" from the lung parenchym of a still-born child. They are described as oval in form, exceedingly variable in size (0.000—0.06 by 0.0013—0.015 mm.), covered by a thin membrane, and either free or in epithelial cells; it is difficult to interpret them in any satisfactory manner. Some of these doubtful structures are discussed as appendices to the next sub-order, the Hemozoinida, to which they show a certain similarity.

An error of the reverse type is that frequently made in the past of diagnosing eggs of parasites as coccidia. Thus nematode eggs have often been reported as coccidia, and eggs of trematodes many times. Were it not for the extremely small size of the structures described, the case of J. J. Thomas, noted above, concerning coccidia in a brain tumor would find its easy explanation in this same manner.

The Hemozoinida, like the Coccidia, are characteristic cell parasites. The period of schizogony or multiplicative reproduction is passed in the host cells, and only very exceptionally in the cells of other organs. These stages have long been known, and with them a few preparatory stages to the sporogonic cycle, although the latter have been entirely incorrectly interpreted as degenerative changes, etc. So far as is known the sporogonic cycle takes place only in the body of another host; and for the Hemozoinida of mammals and birds this host is a blood-sucking insect in which the process of sporogony is carried out in the wall of the alimentary canal, and the sporozoites collect in the salivary glands, whence they are injected by the act of biting into a new host to start anew the schizogonic cycle. The close relationship of these forms to coccidia is evident from a study of the life history, as Doleh indicates most aptly in calling them coccidia adapted to parasitism in the blood system.

The life history may be outlined from that of the aestivo-annual parasite (Fig. 5182). The earliest stage of the parasite which occurs in the erythrocytes is a minute amoeboid body (A) which increases in size and exhibiting considerable amoeboid activity (D-E). In connection with the growth of the organism particles of a black pigment matter, named melanin, are stored up in its protoplasm (F, G). The nucleus of the parasite, at first single, begins to divide rapidly when the organism has reached its maximum size and the daughter nuclei collect about the rim of the organism (H). Radial lines of division appear in the protoplasm (I), and the whole falls into a group of young germs or merozoites (K) about a central residual mass of protoplasm loaded with the pigment already referred to. The merozoites infect new blood cells, and the process of schizogony is repeated until conditions, as yet unknown, bring in a new set of changes.
the starting-point of another cycle, the sexual phase, or sporogony.

The merozoites develop to individuals differently formed from the schizisand of two sorts, the one finely granular and opaque (G'), the other hyaline in appearance with a few conspicuous pigment granules (G*). These forms are shaped like a bean in the species under consideration, and are those previously designated as half-moon or crescentic bodies. When fully grown they desert the corpuscle (II, III) assume a spherical form (I, I'). The macrogamete extrudes a portion of the nuclear substance (K') and is mature. The nucleus of the microgametocyte divides, the parts migrate to the surface and form microgametes by a small accumulation of plasma about each (A'), leaving a large central residual mass. These two gametes copulate, their nuclei fuse, and the product (M) is the starting-point of the sporogonic cycle, the sporont.

The changes leading to the perfection of the sexual cells take place only after the blood has been drawn into the stomach of the new host, the blood-sucking insect. Abnormal stimuli may, however, bring about some of the changes, as in cultures of malarial blood. The copula acquires an amoeboid form (N) necessary for its attainment of a location within the tissue of the new host. This motile stage, which has been denominated the ookinet, is a gregarine-like organism, and penetrates an epithelial cell, where it transforms itself into an immobile spherical oocyst (O). After nuclear division there are formed in the oocyst numerous sporoblasts (P, Q), which, however, never acquire a heavy membrane, i.e., never become sporozocts as in the coccidia. Each sporoblast gives rise to a large number of sporozoites (R, S), which are set free into the body cavity of the insect host by the rupture of the wall of the oocyst. They collect as the result of an evident chemotactic influence in the salivary gland, and are injected into a new host when the insect bites. There they enter the erythrocytes and the life cycle begins anew.

The organisms included in this sub-order are the cause of serious diseases, and their number is being rapidly increased by the investigations of most recent times. Many doubtful forms have also been placed temporarily under this heading, so that it is impossible to give a synopsis of the genus, or to fix the precise limits of the sub-order itself.

Most prominent of the forms which are included here are the parasites of human malaria. Grassi still regards these all as merely varieties of one species. This is clearly doing violence to the ordinary zoological significance of the word. On the other hand, several investigators have grouped them into two genera, a plan which I myself follow, and which appears in other papers. Here they will be treated as three species of one genus in accord with a recently expressed view of Schaudinn, and with the known facts regarding their clinical manifestations, structural differences, and life histories.

The genus Plasmodium includes in addition to these species the parasite of avian malaria also. It was established in 1885 by Marchiafava and Celli, and although the name is employed here in a sense utterly at variance with its meaning as a term in general scientific use, yet the rules of zoological nomenclature call for its retention. The malarial organism was first seen and figured by Kiencke in 1843 without any idea of the significance of the structures viewed. Laveran in 1880 was the first to attach etiologic significance to the structures he described from the erythrocytes in cases of malaria. A large number of investigators participated in the gradual elucidation of the schizogony of these parasites. It was 1896, however, before Manson set forth distinctly the agency of the mosquito in transmitting the disease. Just a year later Ross actually followed for the first time the fate of the parasites of avian malaria in the mosquito's stomach, and their development up to the infection of a new host by the sporozoites. Ross' observations on avian malaria were confirmed soon after by Grassi and other Italian investigators for human species of the malarial parasite.

The complicated terminology in this group, due to the continual changes introduced by various investigators, renders it advisable to give here for general information the table prepared with such success by Lühe, which shows the correspondence in the nomenclature of the chief investigators of recent date. The terminology of Schaudinn, which is followed in this article, has been more generally adopted than any other, and has much in favor of it from every standpoint. (See table below.)

The extensive consideration which the subject has received in previous articles in the Reference Handbook (compare Malaria, Mosquito in Relation to Human Pathology, Plasmodium Malariae) renders it necessary here only to insert a brief diagnosis of the three species, and refer to the articles noted for further details.

**Plasmodium malariae** (Laveran 1883).—(Syn.: Oocystis malariae Laveran 1883; Plasmodium var. quartana Golgi)

<table>
<thead>
<tr>
<th>Schaudinn, 1888 and Lühe, 1900</th>
<th>Ross, 1899</th>
<th>Ross, 1899 and 1900</th>
<th>Ray Lankester, 1900</th>
<th>Harvey Gibson, 1900</th>
<th>Koch, 1899</th>
<th>Grassi, 1899-1909</th>
<th>Grassi, 1900</th>
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<tr>
<td>Schizont</td>
<td>Sporulating form</td>
<td>Sperocyst (young form: amebula s. myxopod)</td>
<td>Oudeterosperma</td>
<td>Full grown parasite</td>
<td>Theihungs-körper</td>
<td>Sporont (fæce spermatozoon)</td>
<td>Anomoeconid (para-sporozoon)</td>
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<td>Microgameto-cyte</td>
<td>Flagellated body</td>
<td>Maleamebula (young form: amebula s. myxopod)</td>
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**REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.**
The Young form in erythrocyte small, unpigmented; movement slow; pigment in coarse granules, first visible in a bout twenty-four hours and peripheral in position. Movement decreasing until in sixty hours after the attack, or twelve hours before the next, the spherical Plasmodia fill almost the entire corpuscle. Having reached a diameter of about 0.007 mm. schizogony begins, and nine to twelve (rarely six or fourteen) merozoites which are very regular (Fig. 5185, e). The mlanin granules move in radial lines and col- lect in the central residual mass. The synchronous release of these germs brings another par- oxyzis at this time, whence the name of quartan fever for the disease induced by this species, which is also designated the quartan parasite. The gametes are few in number, spherical, and characterized by active streaming in the protoplasm. The sporogony of this species in Anopheles goes on at a minimum of 18°C, and stops before the maximum of 30°C is reached. Plas- modium vivax is formed farther north than either of the other human malarial parasites, but does not ex- tend into the tropics.

Plasmodium vivax (Grassi et Feletti).—(Syn.: Hem- amoboa vivax Gr. et Fel. 1892; Pl. var. teretias Golgi 1889; H. Laverani var. tertiana Labbé 1894; Pl. malarum tertianum Labbé 1899.)

Young stages in the erythrocytes are very active. Pigment granules are fine, and light brown in color. The fully grown schizont completely fills the red corpuscle, which is usually swollen and bleached in color. This stage measures 0.008-0.011 mm. in diameter, and produces fifteen to twenty merozoites in schizogony, which requires for its completion just forty-eight hours, whereas the common names of tertian fever and tertian parasite. The pigment forms a solid mass in the centre, and the merozoites form a double ring about it, or more frequently an irregular mass. Schizogony occurs pre- eminently in the spleen. The gametes are abundant at a certain period, of spherical form, and distinguished from occurrence of the disease in the tropics and subtropics. The relation of the body temperature of the host to the development of the parasite is well shown in the accompanying diagram (Fig. 5184).

Plasmodium immaculatum (Grassi et Feletti).—(Syn.: Laverania malarum Gr. et Fel. 1890; Hemamoboa mala- ria praecox Gr. et Fel. 1892; Plasmodium praecox Dollem 1901.)

This is the smallest of all human malarial organisms. Fully grown schizonts measure only 0.003 mm. in diameter. Young form very active; pigment moderate in amount, very fine in peripheral zone. The schizont may also remain unpigmented, and this form has been regarded as a sepa- rate variety. Multiple infec- tion of an erythrocyte is not rare, and the assumption of a signet-ring form is very com- mon. The erythrocyte shrinks during the growth of the para- site. In schizogony seven, ten, or twelve merozoites are formed, rarely twelve to fif- teen, and these are small, being only 0.001-0.0015 mm. in di- ameter. The length of the schizogonic cycle is not well de- termined, as the process takes place in internal or- gans, and the parasite is not generally known. It is apparently irregular, though forty-eight hours seems most probable. The gametes are crescentic or reniform, and originate especially in bone marrow. Further changes have been most carefully followed in this species. In the stomach of Anopheles these crescents become spherical (Fig. 5185) and the microgametes are formed and set free. The fer- tilization is completed by the fusion of a single micro- gamete with a macrogamete; and the resulting motile ookinet (Fig. 5186, a) penetrates the wall, entering first an epithelial cell and coming later to lie between the lay- ers of the wall (Fig. 5186, b). The oocyst forms no spe- cial covering, but increases rapidly in size. Sporoblasts and then sporozoites are formed; the latter have a length of 0.014 mm., and a thickness of 0.001 mm., and are pro- duced to the number of ten thousand in a single oocyst. After the rupture of the latter they accumulate in the salivary gland, lying in the secretion either within the cells or in the duct itself, whence they are expressed in the act of biting (Fig. 5187).

The sporogony requires eight days at a temperature of 28°-30°C., and 18°C. is the minimum temperature for the infection of Anopheles. This species gives rise to the
malarial fever designated as easter-autumnal, pernicious, tropica, etc., and is epidemic only in the tropics and sub-tropics. This is the form which has been rated as a representative of another genus, Laverania malariae, by

many observers. While its separation from the genus Plasmodium is perhaps a convenience, it seems hardly justifiable on scientific grounds, as the differences between it and the other species are not of generic rank.

Uncertain Species.—According to the work of certain investigators, particularly Celli, there exists a true quotidian malarial parasite, which is related to Plasmodium immaculatum, although smaller and completing the schizogony in twenty-four hours. The supposed species is found in Italy particularly in summer and fall, and is regarded by most authors as a sort of Plasmodium immaculatum. Still other forms from tropical regions have been regarded as distinct species without sufficient evidence as yet for this opinion.

There are yet other hematozoa of which it may be said that their exact relationship has not been sufficiently demonstrated to give them a definite place in the system, but which in all probability will be included in this sub-order, though evidently not in the same genus with the malarial organisms just described.

In this connection should be noted the parasite of the spotted fever or tick fever of the Rocky Mountains, a new disease especially virulent in the valley of the Bitter Root River in Montana, where it has been known for twenty years, but present apparently also, though in milder form, in other parts of Montana, Idaho, Wyoming, Nevada, and Eastern Oregon.

Wilson and Chowning were the first to hematozoa of blood cells in stained blood preparations, and to determine that in fresh blood these bodies manifest ameboid movements. These observations have been confirmed by later investigators, and the locomotion is regarded by all as probably the cause of the disease. A brief description of the organism may be given here.

The smallest forms, or the first phase of Wilson and Chowning are intracellular, ovoid bodies and measure 0.0015-0.002 mm. in length by 0.0006 to 0.001 mm. in thickness. They resemble slightly yellow schizonts of malaria, and more strongly the organism of Texas fever of cattle. These bodies occasionally change position in the corpuscle, and according to Anderson project pseudopodia quite rapidly. Two such bodies may lie in a single corpuscle. In the second phase the bodies are solitary in the erythrocytes, oval, ellipsoidal or spherical in form, and from 0.002 to 0.003 mm. thick by 0.003 to 0.005 mm. long. This phase is actively amoeboid with the formation of pseudopodia in various directions. The third phase is seen in pyriform bodies arranged in pairs with the pointed ends approximated, and in rare cases distinctly united by a fine thread. This form is not amoeboid.

Though the parasites are not found in large numbers in the circulating blood, only a few being present in each field of a preparation of freshly drawn blood, yet in the capillaries of tissues removed at autopsies from one to five per cent. of the erythrocytes are infected. This is marked in the lung, spleen, liver, and kidney, where also are found many red cells included in phagocytes, being faintly outlined within the protoplasm of the latter, and each containing a large parasite. In tissues taken some hours after death, the organisms are almost all spheroidal. They are present in the blood at least twenty-four days after recovery.

The organism is apparently transmitted by ticks, and all cases of the disease show a history of tick bites about one week before the onset. Stiles made a provisional determination of some ticks from the region as Dermacentor reticulatus but in correspondence later expressed the view that certain differences though slight justify placing these forms in a new species. Some facts point to the existence of another normal mammalian host for the parasite, and the gray gopher has been indicated as the most probable form. Further study is necessary to establish the character and development of this parasite, its exact systematic position, and its positive relation to the disease. Its superficial resemblance to Pirophora bigemina, the cause of Texas fever in cattle, has already been mentioned.

Myxoscelidium Parker, Beyer, Pothis 1903.—Schizogony unknown; sporogony in Stegomyia fasciata. Only one species, thus far imperfectly known.

Fig. 5187.—Section Through Dorsal Sac of Salivary Gland from Anopheles with Groups of Spezocysts of Plasmodium immaculatum both in gland cells and in duct. Isolated sporozoite at right more highly magnified. (From Lang, after Grass.)

Myxoscelidium steppomyia Parker, Beyer, Pothis 1903 (Fig. 5188).—A fusiform body (oocyst?) 0.003-0.004 mm. long by 0.0015-0.002 mm. broad in lumen of stomach and oesophageal diverticulum, about three days after mosquito has bitten yellow-fever patient; this body is provided with a nucleus. A spherical body (oocyst?) in
the cecal region of the cecum, the cecum itself, and the盲 deger became blind in 1900, and is now known as the blind deger because of its blind cecum.

The Blind deger is a small mammal, typically weighing less than one ounce. It is primarily nocturnal and feeds on fruits, insects, and small animals. The Blind deger has a very specific diet, and its diet is known to be composed of blackberries, which are abundant in the area where it is found. The Blind deger is known for its ability to climb trees and navigate through dense vegetation, which makes it difficult to track. It is also known for its ability to burrow and create underground tunnels, which provides it with a safe and secure habitat. The Blind deger is a solitary animal, and it is usually found alone or in small groups. It is not known to be aggressive towards humans, and it is generally considered to be a docile, non-threatening species.
Sarcosporidia are of importance here, and they are but imperfectly known.

The Sarcosporidia possess an oval, elongate, or sacculate body (Fig. 5189), in which pansporoblasts are formed at a very early period. They parasitize at first immediately the muscle fibres, but by the degeneration of these come to lie in connective tissue and develop to oval or spherical bodies of considerable size. In the youngest stages yet found, uninuclear spheres 0.004–0.005 mm. in diameter with relatively large nuclei (0.002–0.003 mm.) occur in the endoplasm. The protoplasm forms a framework between these young pansporoblasts, which increase in size with age and become also multinuclear. While at the ends of the sacculate body new pansporoblasts are continually being formed, in the older ones nearer the centre the contents divide into many finely granulated pale spheres, the sporoblasts.

In each of the latter is formed a single sporozoite which gradually assumes the definitive form (Fig. 5190, a–d). These sporozoites are usually reniform, sickle-shaped, or crescentic and very small. Some investigators claim to have discovered a polar capsule, which has been partly confirmed by some later observers. Polar filaments are present in some cases (Fig. 5191, b). Theobald Smith has observed that the movement of the sporozoites, and finds that in Sarcocystis muris there is a peculiar gliding with sudden revolutions on the long axis. This is carried out without the assistance of flagella. Smith’s experiments, which were very painstaking and extended over three years, demonstrate for this species directed motion by feeding muscle tissue in which was present the parasite with its ripe, mobile sporozoites. Sarcosporidia are parasitic in vertebrata, chiefly mammalia, and are common in many domestic animals.

Miescher in 1848 found these parasites first as cylindrical sacs in the voluntary muscles of the house mouse. Some years later Rainey found similar structures in the muscles of the pig and the common names of these structures, often visible to the naked eye, are associated with these two investigators. The group has been but little studied, and the system is so imperfectly developed that it is advisable to omit all further mention of it, and to pass at once to a consideration of the one species which has been certainly obtained from the human body.

Sarcocystis Lindemannii (Rivolta 1878).—Syn.: Gregorina Lindemannii Rivolta 1878; Sarcocystis bowmanii Rosenberg 1892; S. Lindemannii Labbé 1899.)

Protoplastic body from the muscle fibres of the vocal cords, from 0.15 to 1.6 mm. long and from 0.077 to 0.17 mm. thick; membrane delicate, somewhat thickened at the ends (Fig. 5191, n), body distinctly chambered (Fig. 5191, e). Sporozoites (d) banana shaped, exceedingly numerous, 0.008–0.009 mm. in length.

The most certain case is that of Baraban and St. Remy, who found this form in the body of a criminal executed at Nancy. All the specimens of the parasite were in the same stage of development. The infected muscle fibres were swollen to fourfold their normal thickness. Several other uncertain cases are on record. As Theobald Smith remarks, the muscular system is not subject to the scrutiny which the viscera undergo in pathological investigations, so that the presence of these forms may be much more frequent and important than appears as yet. In the case of S. muris Smith has shown that the feeding of muscle tissue containing ripe mobile sporozoites to gray and white mice is followed by an invasion of the muscle fibres by the parasites, which readily become recognizable after the forty-fifth day. Nothing is known regarding the development of S. Lindemannii.

The class Infusoria holds the highest rank among Protozoa, and its members are at once distinguished by the presence of peculiar organs of locomotion in the form of fine hair-like protoplasmic processes, the cilia, which are present in at least some part of the life history of all individuals in the group. By virtue of the greatly inferior length, the much larger number present on each animal, and the simple synchronous movement cilia are easily distinguished from flagella. The external zone of ectoplasm is more highly differentiated than in the forms of

Fig. 5190.—Sarcocystis Lindehannii from Human Larynx (except b). a, Longitudinal section of muscle fibre with fully developed sac. × 250. b, Transverse section of same. × 250. c, Section showing chambers emptied of pansporoblasts. × 55. d, Sporozoite. × 150. b, Sarcocystis of S. Blanchard with polar filaments. × 875. (b, From Wieselewski, after Ecke; other figures from Bolbin, after Baraban and St. Remy.)
Protozoan.

Protozoa thus far considered, and the body has in consequence a more permanent form, which tends to acquire in all free species a bilaterally symmetrical structure. In the ectoplasm one finds special contractile fibrils, or myophanes, and peculiar unexplained bodies known as triechysts. The cilia are arranged in rows, and occasionally fuse into vibrating membranes or stylet-shaped masses, giving the appearance of firm ectoplasm forms at the mouth opening (cytostome) a groove (peristome), or a peculiar funnel-shaped pit (cytopharynx), which serves to admit food particles to the interior of the body. A differentiated anal orifice (cytopyge) is only rarely found. The rows of cilia on rows of posterior cilia are always present, and often two or more occur with a more or less extended canal system branching in all directions.

One of the most striking peculiarities is found in the nuclear conditions. Typically two nuclei are present; a large somatic nucleus or macronucleus, which usually lies close to the former. The macronucleus is always single, but there may be several micrornuclei to each cell. The ordinary process of reproduction is fission or gemmation, and in this the macronucleus divides amitotically while the micronucleus undergoes indirect or mitotic division. At times one finds conjugation, or temporary and partial fusion of two individuals with the destruction of the macronuclei and of a portion of each micronuclei. The division of the micronuclei is always single, and the continued existence and reproductive power of the individuals is certain. Certain recent investigations leave this somewhat uncertain. The complicated details of the process find, however, an evident parallel in changes connected with the fertilization of higher forms, or the union of egg and sperm cells.

Encystment is frequent, and the evident means of providing for unfavorable changes in environment, such as drought, temperature changes, etc. In parasitic forms it is connected with the necessary reproductive power of the adult to a new host. In the majority of cases these protozoa are commensals rather than true parasites, and in some instances are even said to be of mutual advantage to the host, and consequently symbiotic in character. The two subclasses are distinguished on the occurrence of the ciliary covering which is constantly present in the Ciliata, save during encystment, but which is found only in the young forms of the Suctoria. The latter are also supplied with sucking tubes for taking in nourishment. They do not furnish any forms found in the class of Protozoa.

The Ciliata are present in large numbers in all fresh-water bodies, and manifest a great variety of structure. They furnish many ectoparasitic species on water-living animals, and also parasitic in higher forms, including man. The various orders into which the Ciliata are divided are based upon the number and arrangement of the cilia in the adult form.

Only two of these orders call for attention here. In the Holotricha there is no spiral zone of prominent cilia or membranelle leading to the cytostome, and the body possesses only small cilia which are more or less generally distributed. The Heterotricha have an adoral spiral zone of larger cilia, but the remainder of the body is uniformly finely dilated.

Of the Holotricha one species has been reported from man. It belongs to the genus Chilodon, the distinctive features of which are included in the description of the species which follows.

**Chilodon dentatus** (DuJardin 1841). (Syn.: *Loxodes dentatus* DuJ. 1841; Ch. dentatus Guiart 1905.)

Oval, 35–55 μ long by 25–35 μ broad, flattened in ventral face, dorsal aspect strongly arched. Anteriorly a flexible membranaceous projection curved toward the left and downward, the row of cilia on the right side. An endoplasmic vacuole, in a thin peripheral layer and forming the anterior projection. Mouth ventral, in anterior portion of the endoplasmic region, normally contracted and hardening to spores of a hyalinoid, *Chlamydomonas* species. Of ventral so as to form almost a complete circle. Two contractile vacuoles, macronucleus large, spherical, in posterior region.

This infusorian has been found once by Guiart, as a parasite of the human intestine in Paris, France. The animals were present in large numbers in the mucus from dysenteric stools. Care was taken to control the source of the parasite and to avoid contamination from external sources, with the result of obtaining from the dejecta on the second day after poisoning the guinea-pig. It is a common free-living species, and must be classed in this instance merely as an accidental parasite. Close examination of fecal discharges will undoubtedly show the occasional occurrence of many such, especially when the resting spores happen to be abundant in the local supply of drinking-water. In this case there is nothing to show that the resting spores did not simply make the passage of the canal, and then develop almost at once in the discharges. The exit of the spores from the body, however, has its significance, and the species to changes in the environment, which has been commented upon by Guiart himself, makes this explanation of the case more probable. One should recall in this connection the record of Schaudinn, that the resting spores open in the colon and an amoeboid organism emerges which does not assume the testate character of the adult until after the feces are discharged from the body.

The order of the Heterotricha, already generally characterized, includes three species under two genera, which have been reported from the human host. The first belongs to the genus *Petechodunum*; the second, to the genus *Ghalydophrys*. The former contains flattened remiform species with a peristome along the concave side from the anterior pole to the cytostome at the centre. The cytopygus is more or less arcuate. The macronucleus is large and nearly central in location. A single contractile vacuole is present. The species of this genus occur as parasites in the alimentary canal of Anura, Myriapoda, and Insecta. A single form has been found twice in the human alimentary canal.

**Petechodunum fusa** Schaudinn, 1899.—Bow-like remiform, somewhat flattened dorsosventrally, left side convex, right concave and notched in the centre. Anterior end bent to the right a little, and on the right side slightly cut out; posterior end broadly rounded (Fig. 518). Length 0.26–0.29 mm. breadth 0.016–0.018 mm. thickness 0.01–0.012 mm. Peristome a narrow longitudinal slit just at right margin of body, extending from near anterior end to middle of body. Cytopygus tubular, short, and without guide spine at entrance. Cilia very fine and delicate as well as short. Endoplasm thin, endoplasm granular, alveolar and without food vacuoles. Contractile vacuole large, located left of middle, near posterior end, emptying through the special anal tube. Macronucleus spheric, 0.006–0.007 mm. in diameter, with chromatia in four or five solid masses near periphery, leaving the intervals filled by a non-staining linin network. Micronucleus 0.001–0.0015 mm. in
Protozoa

Protozoa

Protozoa

REFERENCE HANDBOOK OF THE MEDICAL SCIENCES.

Protozoa

Protozoa

The species has been found only once in Berlin in a patient suffering alternately from diarrhea and constipation. It occurred in large numbers in the feces taken direct from the intestine, and was accompanied by Balantidium micronum and eggs of Anguillicola (i) and Anchylostoma. The species has an especial interest here since the German physicians suggest from the history of the case that the infection may have been obtained in the United States, where the patient lived for some time previously. A pathogenic rôle has not been attributed to the species.

Stiles reports in recent correspondence that he has encountered several cases of clime infection which could not be diagnosed and at the time more exact study was impracticable. The attention of physicians should be directed more carefully to this group of organisms.

Balantidium micronum includes species of oval or ellipsoidal form, circular in transverse, with the anterior end somewhat tapering. The peristome has the form of a flattened funnel with the cytopharynx at its base. Two contractile vacuoles on the right side, two others on the left, with a macronucleus oval or round. The five known species are parasitic in the alimentary canal of man (two species), pig (one species), and amphibia, and in the body cavity of polychaetes annelids. For the distinction of the latter two groups it appears a key to all species is necessary. That given here is taken from Schaudin:

1. Peristome extends to equator of body or further, cytopharynx present....................... 2
2. Peristome much shorter, cytopharynx wanting............ 3
3. One contractile vacuole, macronucleus round, cyst spherical............... B. entozoon Clap. and Lachm.
4. One contractile vacuole, macronucleus oval, cyst spherical............... B. micronum Schaudin
5. Two contractile vacuoles....................... 4
6. Body elongated, spindle-shaped, or cylindrical, B. elongatum Stein

Schaudin

The species inhabits the colon of man and the pig. In the latter it occurs also in the rectum and cecum, and is present regularly in large numbers. The pig may be regarded as the normal host, and in it this species excites no abnormal symptoms. The encysted forms evaucated with cysts are supposed to bring about the transfer of the species all the more easily that the pig is coprophagous; and yet experimental infection has been unsuccessful even in the pig. Grassi and Calandruccio have demonstrated that experimental infection of man is not successful in the case of healthy individuals. The occasional introduction of encysted forms may, however, bring about successful colonization of the canal whenever any pathologic condition exists in the colon, although Grassi and Calandruccio argue from the slight difference in size and the failure of their experiments that the forms found in man are not of the same species as those from the pig. These conclusions do not seem to have found even limited acceptance.

Malmsten discovered Balantidium coli in 1857 in a man who had recovered from an attack of cholera two years before, but had since suffered from diarrhea. The para
Protozoa as secondary, and look upon bacteria as primarily responsible for the lesions. This species is known to occur abundantly in some parts of this country as a parasite of the pig, and its more frequent presence in the human host than in other animals may possibly have led to the idea that the pig was the intermediate host.

**Fig. 519.—Balantidium minutum.** Living. Abbreviations as before. Magnified. (After Schaudinn.)

Body compressed pyriform or oval (Fig. 519). Length 0.02–0.083 mm.; breadth 0.014–0.02 mm., or in the ratio 3:2. Anterior end bluntly pointed, often slightly twisted dextral or sinistral. Posterior end broadly rounded. Peristome a slender cleft, broader anteriorly, pointed concen- teriorly and deeper; extending from anterior tip to centre of body; in the living animal continually opening and closing; left margin with hyaline membrane. Adoral cilia heavier and longer than those of the body generally, only on the left peristome margin beneath the membrane. Body cilia long (0.007–0.008 mm.) slender. Hyaline ecto- plast thin, distinct from granular endoplasm, which contains many vacuoles. These are filled with fine granules, and large food masses or excretory crystals are not present. Contained in a single vacuole, near posterior pole, on left side. No permanent cytopyge. Macronucleus spherical 0.006–0.007 mm. in diameter; centrally located. Micronucleus single, anterior to macronucleus at its surface, 0.061 mm. in diameter. Division occurs, but con- jugation has not been observed. Cyst oval.

Reported twice, once in company with *Nepetatherus foba* (q. v.) and once in Berlin also without that species. In both cases this form was abundant during the diarrhoea, but with the exception of a few cysts, disappeared as soon as the stools became firmer. Purgatives brought the infusorians again in numbers into the stools. This condition indicates that they inhabit the small intestine, perhaps the duodenum, rather than the colon, and make their appearance when carried outwards by the more fluid contents and rapid passage of the canal. As other species of the genus are harmless commensals in the canal of Amphibia, this species is probably not pathogenic. It should be kept in mind that confusion of *B. coli* and *B. minutum* may occur if the examination is not made with precision, and perhaps some cases of the former, already on record, actually concern the latter species.

As pseudo-infusoria may be designated a long series of structures reported from various sources, and often the object of repeated discovery by those unfamiliar with the field. Thus in mucus or spoum in case of affection of the air passages, bodies moved by cilia have been inter- preted as genuine parasites and assigned an etiological rôle in the disease. In contravention of this view may be urged the variable and irregular form of such bodies, their rapid and special degeneration and their source, which amply demonstrate their origin as detached ciliated cells from bronchi, trachea, or nasal cavity. Such bodies are the asthma parasites of Salisbury, and the protozoa of whooping-cough described by D'Her and Kurlow. Much less worthy of serious attention are the reports of various writers, especially Lindner, that certain forms, well known as free-living species, namely, unstalked vorticellids, are the cause of various gastric disturbances in man and certain domestic animals. The statement of Schaudinn, that he has found repeatedly active vorticel- lids in fresh faces, but only after water enemata, is suf- ficient indication of the means by which such marvellous discoveries as those of Lindner and others are achieved. It is more recently I was asked to examine a slide containing organisms from fresh urine, and these were not echino- coccus bladders as diagnosed, but unmistakably free living forms, and probably contracted rosettes whose presence was due to the contamination of the vessel, or possibly of the sample of urine examined.

**Henry B. Ward.**

**Principal Articles Consulted.**


On the Cultivation of *Trypanosoma Levisi.* Von Rhein's Contributions to Medical Research, p. 548, 1903.


**Addendum.**

"Protozoa in Scarlet Fever?"—In four cases of scarlet fever, which came to autopsy at the Boston City Hospital, there was found a series of bodies which strongly suggest the different stages in the development of a pro- tozoan. These bodies occur in the epithelium of the skin and tongue, between these cells, and in the su- perficial lymph vessels and spaces of the corium (see Plate LXII). For description they may be divided into two groups.

"The first group consists of a series of bodies varying in size from 3 to 7 μ. Structurally they are composed of a finely granular, closely meshed reticulum. Sometimes they contain small vacuoles. Their frequently irregular and elongated forms suggest fixation while in ameboid motion."

The bodies of the second group are radiated in structure and measure 4–6 μ in diameter. They contain a central body from which radiate a comparatively large number of narrow segments. All stages occur between radiate bodies or rosettes just forming, and others where the seg- ments are enlarging and leaving the central body to form the small granular forms already described. These bodies are brought out by staining in eosin followed by alkaline methylene blue after fixation in Zenker's fluid. They stain a clear blue in fairly well-marked contrast to the purplish nuclei and the pale pink protoplasm of the cells. Other staining methods give no differentiation of the bodies.

"The evidence that these bodies represent different stages in the growth of a protozoan is based on morpho- logical data only, and necessarily is far from conclusive.

*This communication and the accompanying photographs were not received until the main article had already been set up in type. Editors.*
Figs. 1 and 2 show numerous large and small scarlet-fever bodies in and between the epithelial cells of the rete mucosum. In Fig. 1 is a large body in a lymph space of the corium just underneath the epidermis. Several of the bodies suggest fixation while in amoeboid motion.

Figs. 3, 5, and 6 are coarsely reticulated forms which may be degenerated forms of the scarlet-fever bodies, or stages in sporogony.

Figs. 4, 8, and 9 probably represent stages preceding the radiate bodies. In Fig. 9 the bodies lie in a lymph space. It shows also four small forms which apparently have just freed themselves from a rosette.

Figs. 7, 10, 11, 12, 13, 14, and 15 show different stages in the development of the radiate bodies.

Fig. 10 is the earliest stage; there is a distinct central body and a definite regular arrangement of granules at the periphery. Figs. 7, 11, and 12 show a little later stage of development; 11 and 12 are optical sections, while 7 is a surface view. Moreover, in Fig. 7 the body lies free in a lymph space in the corium. The segments begin to show a certain amount of lateral separation from each other.

Fig. 13 is a still later stage; the segments are increasing in size and are more or less free from each other, although most of them are still attached to the central body. In Fig. 14 the segments are all free and enlarging, although still grouped around the central body. In Fig. 15 three bodies are still grouped around the central body, which is free.
Protozoan-like Bodies found in four cases of Scarlet Fever
(After F. B. Mallory)

Copied in monochrome tint from the colored drawings in the original paper
Journal of Medical Research, No 4, Vol X, 1904.
Protozoa.

Radium.

Their discovery may, however, prove to be the first step in clearing up the etiology of scarlet fever.

"Morphologically the bodies resemble fairly closely the different stages in the sexual development (schizogony) of the malarial organisms. Comparing them with the tertiary malarial parasite under the same conditions of fixation and staining, they seem to be about one-third larger, and to have about twice as many segments in the rosettes."

"The accompanying illustrations (Plate LXI.) are a copy in black and white of the plate of colored drawings in the original paper."*

While these bodies must be studied in the living condition to demonstrate beyond question their protozoan nature, and while still further evidence must be adduced before their etiological relation to scarlet fever can be regarded as demonstrated, yet Dr. Mallory's work is of great importance and a strong presumption in favor of the view which he advocates. For his courtesy in furnishing these results in advance of the appearance of the article itself sincere thanks are due.

H. B. W.

RADIUM.—Radium is a radioactive substance supposed to be a new element. Professors Curie and Demaray have isolated in small quantity and tested what they consider to be pure radium, obtained from their samples a characteristic spectrum, and have determined the atomic weight to be 225. On account of the rarity and great difficulty and cost of isolating radium it is used in the form of a bromide or chloride.

Discovery of Radium.—The discovery of radium is due to investigations upon radioactive substances. In 1896 M. Henri Becquerel, member of the Institute of France, reported the discovery that uranium gave off radiant energy having many of the properties exhibited by the radiations from x-rays.

The radiations from uranium were given the name of Becquerel rays, from the distinguished scientist who discovered them. These rays have the property of discharging electrified bodies and of producing chemical changes, some of which are only used in photography, in those respects being similar to the x-rays.

Uranium was first discovered in 1789 by the German chemist Klaproth, and named by him from the planet "Uranus." Uranium, though widely distributed, is never found in large amounts, and forms several minerals. The most common of these is uraninite, commonly known as pitchblende. It contains about eighty per cent. of uranium. The pitchblende which contains the largest amount of radioactive substances is the Bohemian pitchblende; but it is found in Saxony, Cornwall (England), and in Colorado (United States).

Professor Curie and Mme. Curie, in investigating the Becquerel radiations from uranium found that some sample of pitchblende, from which the uranium had been extracted, gave forth radiations much more powerful than any they had found, having, in fact, four times the radioactivity of metallic uranium. They concluded that uranium being absent, the radiations were due to some unknown substance in the pitchblende, and following out this they discovered, in 1898, a substance to which they gave the name of "polonium." Polonium passes more rays through aluminum than uranium does, but these rays do not penetrate glass, are readily absorbed by minerals, and are cut off by thin paper. In the same year following up the discovery of polonium, Mme. and M. Curie and M. Benoit isolated a second substance from pitchblende which possesses many of the chemical characteristics of uranium, but is much more powerful. To this they gave the name "radium."

Properties of Radium.—Radium is one of the most peculiar substances known to science, and produces phenomena which were hitherto unknown as existing in any chemical element or chemical combination: (a) it glows constantly with a visible light; (b) it gives off constantly a certain degree of heat; (c) it produces electrical effects similar to those produced by the x-rays; (d) it causes certain chemicals to fluoresce; (e) it reduces the silver salts ordinarily used in photography; (f) it transforms white into red phosphorus, and produces other transformations, such as changing the color of glass, porcelain, white paper, rock salt, etc.; (g) it has a distinct effect upon living tissue.

Nature of Radium Radiations.—The discovery of x-ray radiations and radium radiations has given rise to many ingenious theories, but experiments appear to show a distinct difference between radium rays and x-rays and the emanations from radium. Radium rays like x-rays pass through glass and substances opaque to ordinary light, while radium emanations are of peculiar character and appear to be more like a vapor. These emanations do not pass through glass, but settle upon all objects with which they come in contact, and like vapor of water may be condensed by extreme cold. The emanations from radium produce radioactivity in other substances, the result being, so far as is known, that all substances may be rendered radioactive through the influence of radium emanations. Substances so rendered radioactive present to a degree all the phenomena which radium itself presents, and when so charged retain the properties of radium for varying periods of time. The Curies have determined that substances thus rendered radioactive retain their induced radioactivity for a longer time if they are not exposed to the emanations than if they are exposed to them, and in such cases the induced radioactivity diminishes one-half every four days, while in substances not so guarded it diminishes one-half every twenty-eight minutes.

Nature and Measurements of Radium Radiations.

There are three entirely distinct types of rays emanating from radium. These are known as the "α, β, γ" rays.

The α-ray is the least penetrating, losing about one-half of their intensity if passed through a thickness of about 0.0065 cm. thickness. The β-rays are much more penetrating and much longer, and correspond in every particular to the characteristics of cathode rays. They are readily deflected by a magnet, discharge electrified bodies, etc.

The γ-rays are the rays possessing the greatest penetrating power. These rays will produce radioactivity through the air at a distance of four feet or more, and are much more penetrating than the α-rays that they require aluminum 8 cm. in thickness to reduce their intensity one-half.

The radioactivity of radium compounds is measured in terms of uranium, this element being taken as a standard. Professor Curie states that radium is about one million times the radioactivity of uranium, but from the rarity of the substance and the difficulty of obtaining it in a pure form, the radium compounds which have so far been available for experiment have rarely been above a radioactivity of 7,000. The quantity of radioactivity of radium compounds so far produced has been exceedingly small and the cost is very great. Professor Curie states that it would take five thousand tons of uranium residue to produce a kilogram of radium at a cost of about $2,000 per ton.

Heat-Producing Properties.—Radium has the remarkable property of maintaining its temperature at about 1.5° C. above its surroundings. Heat production like light production from radium appears to be made without any change in the radium and without any loss of weight. This remarkable force production as exhibited by heat production can be appreciated when it is understood that radium radiates enough heat to melt more than its own weight of ice every hour, and to continue, so far as is known, this force production for an indefinite period.

Light and Fluorescence.—When a tube containing radium is viewed in the dark it is seen to emit a distinctly visible light. The light emitted is of uniform quality and is produced indefinitely and, so far as is known, without any change in the radium itself. When the rays from radium are directed upon the double cyanide of platinum and barium, tungstate of calcium, and certain

other chemicals which fluoresce under the action of the x-ray, the radiations from radium cause these substances to glow with a visible light; the properties of the radiation being like those from x-rays. A sufficient quantity of radium has never been obtained to allow of the practical use of the fluorescence so obtained in the way in which the fluoroscope is used with x-rays, but it is possible that with a sufficient quantity of radi- um a fluorescence equal to that of the x-rays could be produced.

Photochemical Effects.—When the rays from radium are directed upon a sensitized photographic plate from which all ordinary light is excluded by having the plate enveloped in black paper, an image can be produced, showing outlines of the transparent spots. Like the fluorescent effects of radium the photochemical effects have not as yet been made of practical value. Practical results may, however, be possible, provided radium can be obtained in sufficient quantities and its action can be controlled by suitable photochemical or photographic filters.

Vitochromatic Effects.—The effect produced by the radiations from radium on living tissue are most remarkable. These effects, in certain ways, resemble the effects produced by x-rays, but appear also to have peculiar properties which so far have not been found to be produced by x-rays. Radium rays, like x-rays, are capable of producing "burns." The discovery of this effect of radium was made by Professor Becquerel, who, while journeying in Paris in the fall of 1898, was able to show that a small tube of radium. About a fortnight later the skin under the pocket began to redden and fall away, and finally a deep and painful sore formed which lasted several weeks in healing. Like the burns produced by x-rays, this will not affect the epidermis or cutis, but will result in the emaciation from radium its germinating power was destroyed.

M. Bánysz, in experiments at the Pasteur Institute, found that the emaciation from radium produced remarkable effects upon rabbits, guine-pigs, and other small animals. He found that radium has the remarkable power of so interfering with organic processes as to inhibit growth and even destroy life. A small amount of radium suspended over a cage containing mice will, after a few days, cause loss of hair and blindness, followed later by death. The same experimenter reports that exposure to the radiations from radium will cause arrest of development in certain lower organic forms. He exposed the larvae of Ephesia kuehniella in a glass flask to the emanations from radium for a few hours. After a few weeks it was found that most of the larvae were killed, but that a few had escaped the destructive action of the rays by crawling into distant corners of the flask where they were still living, but living in a condition in which the normal larval form had been changed into moths.

M. Bohm has shown that radium may so modify various lower forms of life as to produce "monsters," and he has caused remarkable deviations from the original type in tadpoles exposed to radium emanations.

The vitochromatic effect of radium seems to be particularly expended upon the skin and subcutaneous tissues and the nervous system. Thus, Bánysz reports that the application of a tube containing a salt of radium to the skin produces an ulcer in from eight to twenty days. A few moments' application produces congestion of the skin. When applied to the skin of a rabbit destruction of the epidermis follows, but when applied under the skin there is only a feeble reaction on the epidermis but its action is noted upon the nerve centres of all animals subjected to experiment. This action, however, was comparatively feeble in those whose osseous tissues protected the nerve centres. Application of tubes containing the salt to the cranial caused paresis, ataxia, and convulsions, followed later by death.

Professor Curie introduced a few milligrams beneath the skin of a mouse by piercing the vertebral column, causing death of the mouse in three hours. The rays of radium have a direct effect upon the optic nerve. This was shown by Giesel, who found that when radium salts were brought near the closed eyes a sensa
tion of light was produced. When small quantities of radium are applied to the cornea the result is a blinding which gives rise to phosphorescence of the sensory fibers of the eye and also to effect upon the nerves of the retina. Prof. M. Javal proposes a diagnostic use of this phenomenon, and suggests that blindness with alteration of the retina can be distinguished from glaucoma by the opacity, because patients with the latter condition see rays from radium as well as those of sound vision, while patients who have alteration of the retina have no sensation of light when a salt of radium is placed near the eyes.

Therapeutic Uses.—Radium is so like that of the x-rays that its use for the cure of conditions for which the x-rays have been used was at once suggested. Experiments seem to show that the vitochromatic action of the rays of radium are much more powerful than those of x-rays. The probability, when radium can be produced in sufficient quantity and its action properly controlled, that it will be a valuable therapeutic agent. So far, its use has been mainly confined to the treatment of lupus vulgaris and superficial skin diseases. Favorable reports of results of its use in these diseases have been given by a number of clinicians.

Danlos reports a case of lupus of the face, exposed to the action of a salt of radium which had a radioactivity of 10,000,000 from twenty to sixty-six hours, with the result of the disappearance of the disease and with the formation of a smooth, white cicatrix. Other clinicians have reported equally favorable results and have called attention to the good effect as shown by the smooth, soft, and time to the emaciation from radium its germinating power was destroyed.

For therapeutic use the radium compounds have in some cases advantages over the x-ray. In superficial diseases of the skin and mucous membrane these radium compounds, being enclosed in small hermetically sealed glass receptacles, can be used for any number of cases, and this apparently with more certainty of definite results, so far as tissue reactions are concerned, than can be obtained from the radiations from x-ray tubes.

SKIN AND ITS APPENDAGES: ANATOMY.—The skin, or integumentum commune, of the body acts as a covering and a protection for the deeper portions, besides being an organ of secretion, of excretion, of special senses, —the sense of touch,—of common sensation, and the conservator of animal heat. Embryologically, it is developed from those two primitive layers of the blastoderm, the ectoderm and the mesoderm, which are formed by the cellular division of the impassaged ovule. The epidermis, or most external layer of the skin, is formed from the ectoderm, while a superficial portion of the mesoderm furnishes the remaining constituent parts—the corium, or cutis vera, and the subcutaneous or fatty tissue.

GENERAL CHARACTERISTICS.—When fully formed the skin can be regarded as a completely closed sac, which