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 animal 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.

Küchenmeister 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 must be self-evident that the turning of the embryo 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.

Martinotti in the situs transversus of the single born emphasizes the condition of the vena omphalo-mesenterica, first mentioned by Dareste. 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 reacts in a very sensitive way toward the cause of situs transversus.

Marchand 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 vena omphalo-mesenterica the cause of the right position of the stomach. In a more recent monograph Marchand states it as his belief that the development of the vena omphalo-mesenterica can have no influence upon the rotation of the stomach.

Lochte advances 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 veins, while those of situs transversus totalis, on the other hand, are associated with corresponding right-sided veins.

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 acquired 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 leukæmia, 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 dislocated heart. This fact was recently brought to my attention.

Gruber refers to the following errors in diagnosis. In one case of transposition a pain 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, in the right hypochondrium; from 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 instead of 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, 19 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 normally fruitful. One gave birth to twelve children. Among the 79, 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.

The lungs were transposed in 35 of 71 cases; the right had two lobes, and the left three. In 2 cases they were 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.

H. Steinhauser mentions the fact that in the operation of œsophagotomy, it is well to know that the œsophagus 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.

In 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 Schrötter 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 Arneill.

TRAUMATOL—iodocresol, orthocresol iodide, $C_6H_4.CH_3.OI$—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.

W. A. Bastedo.

TREMATODA.*—The class Trematoda, or Flukes, constitutes one of the prominent subdivisions of the branch or phylum Plathelminthes, the characteristics of which were outlined under the Cestoda. The group was recognized as distinct in 1800 by J. G. H. Zeder, a practising physician in Germany, who with great clearness of vision separated the then accepted class of Helminthes or intestinal worms into five groups of closely related forms. These groups received in 1809 at the hands of K. A. Rudolphi, the celebrated Berlin helminthologist, the scientific names of Nematoda, Acanthocephala, Trematoda, Cestoda, and Cystica. 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 Helminthes, making as a natural group the flatworms in which are now included the flukes, the tapeworms, and the free living flatworms, as three great classes of the phylum designated Plathelminthes.

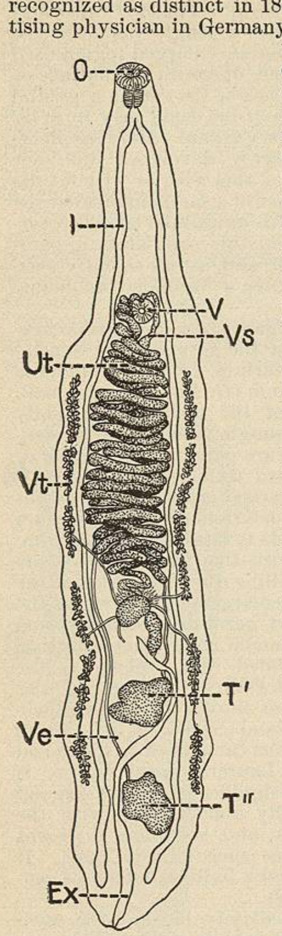

FIG. 4772.—*Opisthorchis pseudofelineus* Ward. From liver of cat. *Ex*, Excretory bladder; *I*, intestinal crura; *O*, oral sucker; *T′*, *T″*, testes; *Ut*, uterus; *V*, ventral sucker; *Vt*, vitellaria; *Ve*, vas efferens; *Vs*, vesicula seminalis. × 7. (Original.)

In certain features, such as the simple 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 do the Cestoda, although all of the species included in both classes are parasitic. The consistent parasitic habit, in which the flukes resemble the tapeworms, is varied by a modification in degree among the flukes which serves to show their relation also to free living species and contrasts strongly with the intensive endoparasitism of the Cestoda. Thus among the flukes there are not only the endoparasitic species, but also such as are ectoparasitic and preserve in some degree those features of free living forms that are lost with the assumption of endoparasitic existence. Withal the group 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 chitinous 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. It was formerly construed as such, and the 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 with the basal surface of the so-called cuticula. Some of these cells are especially developed as unicellular glands.

The dermomuscular sac lies just within the cuticula and consists of layers of circular, longitudinal, and diagonal fibres which surround the body, though of varying thickness in different regions. Running obliquely from one surface to the other occur also dorsoventral or parenchymatous muscles which are inserted on the cuticula. Especial development of the muscular layers is found in the suckers, which consist of muscle fibres extending in three directions and designated as equatorial, meridional, and radial; these correspond to the circular, longitudinal, and dorsoventral muscles respectively. In addition one finds a special set of muscles radiating from the sucker through the tissue. 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 high development of the muscular system, associated with the absence of special skeletal structures, 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 cuticular 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 and in all higher forms is surrounded by the oral sucker (*O*, Fig. 4772). In lower members of the group, two or more suckers may lie near the oral opening or the latter may be entirely unarmed. In form the alimentary canal may be rhabdocœl, though much more frequently it is of the triclad type. 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 œsophagus. It is thin-walled and not digestive in function, though frequently numbers of unicellular salivary glands are connected with it. Near its oral end a prominent sphincter muscle forms a bulbous mass known as the pharynx. By its action the oral sucker is closed posteriorly to act as a simple organ of prehension, or stands in open communication with the canal, for which it serves as an aid in the ingestion of food.


FIG. 4773.—Flame Cell and Excretory Tubule of *Azygia tereticollis* (R.) × 700. (After Looss.)

The simple œsophagus divides into two intestinal crura (*I*, Fig. 4772), which form the digestive and absorptive region of the canal. They are blind sacs, usually symmetrically placed right and left, but of variable length and character. In some genera they are so short as not to reach the sides of the body; in other cases they extend to the posterior end, and may even be connected by several commissures or anastomoses. Usually the crura are of uniform calibre 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 subsist on the intestinal contents and secretions of the host, but also ingest epithelial cells and blood, thus giving rise in some cases

* A general discussion of parasitism and its effects is to be found under the heading *Parasites*.

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Traumatol.
Trematoda.

to severe hepatic or intestinal disturbances, the gravity of which is proportionate to the extent of the invasion.

The excretory system agrees in general with that of the Cestoda. One finds a variable number of primitive nephridia or "flame cells" (Fig. 4773), scattered throughout the tissue. These cells are stellate in form, with a huge bunch of cilia which lie on one side in a narrow canal. The constant motion of the group of cilia simulates the flickering of a candle flame, whence the name. The tubules from these flame cells unite into larger ducts, and ultimately combine in a single vessel, which opens at the posterior end of the body by a simple 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 (*ves*, Fig. 4774).

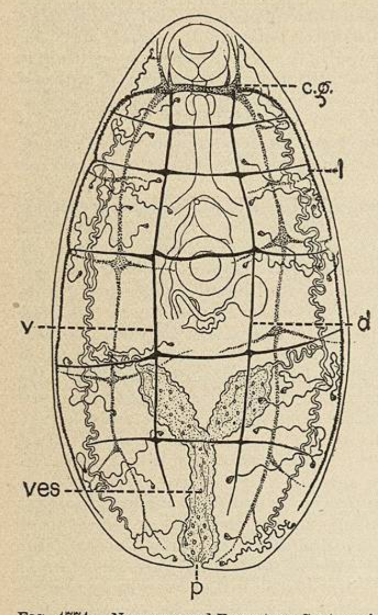

FIG. 4774.—Nervous and Excretory Systems in *Opisthioglype endoloba* (Duj.). *c.g.*, Cerebral ganglion; *d*, dorsal, *l*, lateral, *v*, ventral nerve trunks; *p*, excretory pore; *ves*, excretory bladder. × 30. (After Looss.)

The system, which was formerly called a water vascular system, contains a clear fluid, sometimes slightly tinted, with occasional granules or concretions. It is produced by the activity probably of the terminal cells, the cilia of which serve to maintain movement. The presence of uric acid in the fluid is sufficient evidence of its excretory nature.

The nervous system is poorly developed in accord with the parasitic habit of the group. It consists of two small lateral aggregations of ganglion cells (*c.g.*, Fig. 4774) near the pharynx which are joined by a ring of fibres that encircles the œsophagus, and of nerves extending anteriad and posteriad from these ganglia. The three pairs passing anteriad are short and innervate the oral sucker with adjacent dermal areas, muscles, and primitive sense organs. The posterior nerves form dorsal, (*d*), lateral (*l*), and ventral (*v*) paired cords. 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 dermal 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 larvæ as well as in ectoparasitic 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 variations toward a lobed condition, or even to a dendritic form. The two vasa efferentia 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 a genital cloaca at the common genital pore, and the terminal portion of the canal may form by eversion a protrusible 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 enclosed in a sac denominated the 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 lateral to the intestinal crura. Their extent is of importance in specific determinations. The duct from each vitelline gland tends toward the germarium, and near this organ unites with that from the opposite side in a common yolk or vitelline duct, on which at the junction there is at times an enlargement known as the vitelline reservoir. 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 (*Sg*, 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 ectoparasitic forms; and, according to recent observations, still functions as such in rare cases. It may bear near the proximal end a bulbous lateral expansion, the seminal receptacle (*R*).

The ootype expands immediately beyond the shell gland to form the uterus (*Ut*), which as a long convoluted tube fills the major portion of the body with its coils crowded with opaque brown-shelled eggs. In the portion of the uterus which 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 metraterm. 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 coition. 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 ordinarily in the median line 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.

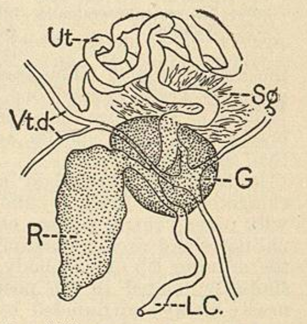

FIG. 4775.—Female Sexual Organs of *Opisthorchis pseudofelineus* Ward. Highly magnified to show relation of ducts. *G*, Germarium; *LC.*, Laurer's canal; *R*, seminal receptacle; *Sg*, shell gland; *Ut*, beginning of uterus; *Vt.d*, vitelline ducts. (Original.)

In the arrangement of the reproductive organs one finds the double condition designated sexual amphitypy, 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 Opisthorchiinæ, where it seems to be very common; it has also been shown to exist among the Dicrocœliinæ, 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 Fasciolidæ, 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 ellipsoidal, rarely flattened asymmetrically. It is provided with a heavy chitinous shell which is transparent when first formed, but darkens soon in the first coils of the uterus to a deep yellowish-brown, which is almost entirely opaque. In ectoparasitic 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 *Schistosoma hæmatobium*. 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 coccidia.

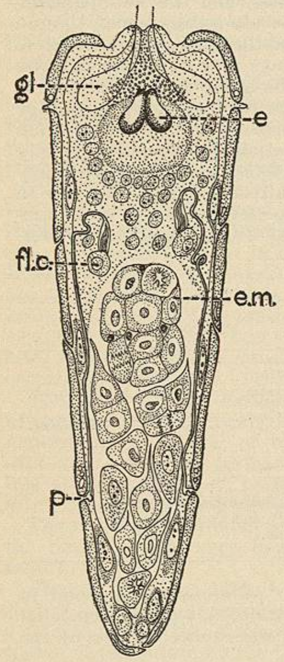

FIG. 4776.—Miracidium of *Fasciola hepatica* (L.); in cross section, showing eye spot (*e*), embryonic cell masses (*e.m.*), flame cells *fl.c.*), cephalic glands (*gl.*), and excretory pore (*p*). Much magnified. (After Coe.)

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, fæces, or rarely urine.

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 (*fl.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 cell 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 rhabdocœl alimentary canal, two short locomotor protuberances, and an orifice known as the birth opening through which the new brood escapes.

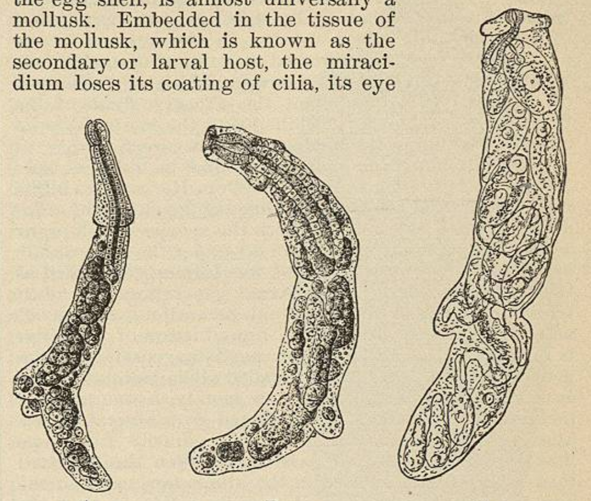
A. B. C.

FIG. 4777.—Rediæ of *Fasciola hepatica* (L.). × 120. *A*, Young specimen with cell masses just forming; *B*, older individual with young rediæ developing; *C*, form with developing cercariæ. (After Leuckart.)

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 produced 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 ventral sucker as well as an oral, a triclad 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 distome, 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,

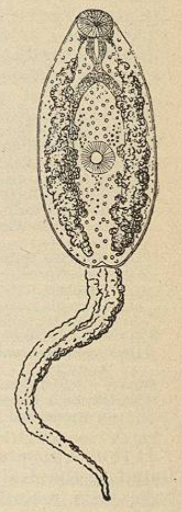
FIG. 4778.—Free Cercaria of *Fasciola hepatica* (L.). Magnified. (After Leuckart.)

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 dermal glands 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. The following table, taken from Hertwig, 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 premature parthenogenesis or pædogenesis, and the alternation is called alloiogenesis. 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 engulfed with drinking-water by chance, or bores its way into the body of the water-inhabiting mollusk which it seeks out.

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 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 hæmatobium*, probably introduced from Africa to the southeastern States, and the Asiatic fluke, *Opisthorchis sinensis*, undoubtedly brought to the Pacific coast from the 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 invertebrates. 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 adnexa, the lungs and liver, are favorite seats of these parasites, but the latter are not wanting in the genito-urinary ducts, where for instance 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 Wes-*

Development of the Distomes.

	Simple.		Ordinary.		Complicated.	
First generation....	Miracidium........ Sporocystis.........	Water............. Host I. (Mollusk)..	Miracidium........ Sporocystis (possibly also redia).	Water............. Host I. (Mollusk)..	Miracidium........ Sporocystis........	Water. Host I. (Mollusk).
Second generation .	Encysted distome.. Sexually mature distome.	Host I............. Host II............	Cercaria.......... Encysted distome.. Sexually mature distome.	Water............. Host II............ Host III...........	Redia.............	Host I. (Mollusk).
Third generation...	....	....	....	....	Cercaria.......... Encysted distome.. Sexually mature distome.	Water. Host II. Host III.

Thus far only thirteen species of fluke have been listed as human parasites; they are as follows:

Family: Paramphistomidæ.
  Gastrodiscus hominis.
Family: Fasciolidæ.
  Fasciola hepatica.—Species recorded in United States of America.
  Fasciola angusta.
  Fasciolopsis Buski.
  Fasciolopsis Rathouisi.
  Paragonimus Westermanii.—Species recorded in United States of America.
  Opisthorchis felineus.
  Opisthorchis sinensis.—Recorded from man in United States of America.
  Opisthorchis noverca.
  Metorchis truncatus.
  Heterophyes heterophyes.
  Dicrocœlium lanceatum.—Species recorded in United States of America.
Family: Schistosomidæ.
  Schistosoma hæmatobium.—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 hæmatobium*) was certainly acquired in other lands and apparently has not gained a footing in our own, while the same is probably true of the other, 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

termanii, is found in pairs in pulmonary cysts, and in rare instances such an association in pairs is connected with the secondarily acquired diœcious 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 as 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.—Ectoparasitic forms with powerfully developed organs of attachment; excretory organs open separately on the dorsum; development direct. Parasitic on body and gills of fishes chiefly. No human parasites.

Order Aspidocotylea.—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 Malacocotylea.—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 hermaphroditic with sexual pore ventral; excretory pore posterior. Always endoparasitic in vertebrata. According to mode of development divisible into two groups:

(*a*) *Metastatica.* Development without alternation of generations, but with two larval forms and change of hosts. No human parasites.

(*b*) *Digenea.* Development complicated by alternation of asexual generations (sporocyst, redia) with sexual generation. One or more changes of host. All human trematode parasites fall in a few families of this very large and varied group, viz.: Paramphistomidæ, Fasciolidæ, Schisto somidæ.

The family of the Paramphistomidæ is characterized by a terminal sucker, dorsal to which the excretory pore is located. The genital pore lies in 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.—Paramphistomidæ 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 outpocketings.

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

Gastrodiscus hominis (Lewis and McConnell 1876.)—(Syn.: *Amphistomum hominis* Lewis and McConnell 1876.) Body 5–8 mm. long, 3–4 mm. broad, reddish when living. Genital pore at bifurcation of intestinal crura. 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 cæcum and colon 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 Leuckart never more than twelve individuals in a single host, which militates against the idea that it was only an occasional parasite.

The family of the Fasciolidæ is characterized by the presence of oral and ventral suckers, by the genital pore ventral, rarely lateral or terminal; always hermaphroditic, two testes, one germarium, with receptaculum seminis or Laurer's canal, or both, and with paired lateral often highly branched vitellaria.

The majority of human trematode parasites fall within the limits of this very large and highly differentiated family.

Fasciola Linnæus 1758.—Large Fasciolidæ with leaf-shaped body, the anterior end of which has the form of a conical cap or tip, distinctly set off from the posterior region; acetabulum on the boundary of the two regions, large and powerful. Œsophagus short, with pharynx; intestinal crura reaching almost to posterior end near the median line of the body, with short branches on median side and with long, highly dendritic branches on lateral side. Excretory system much branched, reservoir a long median sac. Genital pore in midventral line in front of acetabulum; germarium in front of testes and transverse yolk duct, highly dendritic, as also the testes which are located obliquely behind one another and posterior to transverse yolk duct; uterus in form of a rosette in front of germ glands; vitellaria on sides even to posterior end, well developed. Laurer's canal present, receptaculum seminis wanting. Eggs large, not numerous, developing after deposition. Parasitic in gall ducts of herbivora, more rarely omnivora.

Fasciola hepatica L. 1758.—(Syn.: *Distoma hepaticum* Retzius 1786; *Fasciola humana* Gmelin 1790. *Distomum caviæ* Sonsino 1890; *Cladocœlium hepaticum* Stossich 1892). Body flattened like a leaf (Fig. 4779), reddish-brown in color, 20–30, rarely 35–50 mm. long, 5 or 8–13 mm. broad, with anterior region 4–5 mm. long, and distinctly set off from the posterior; posterior extremity bluntly pointed. Dermal spines over entire body except a small area near the posterior end. Oral sucker terminal, nearly spherical, about 1 mm. in diameter, acetabulum at junction of two regions about 1.6 mm. in diameter, spherical with triangular aperture. Pharyngeal bulb covering nearly entire œsophagus, intestinal crura, with numerous dendritic branches directed laterad; vitellaria, lateral, dendritic, both dorsal and ventral of intestine. Germarium and testes both dendritic, former anterior, latter posterior to transverse yolk duct and side by side. Eggs oval, 0.130–0.145 mm. long by 0.07–0.09 mm. broad, deposited before commencement of cleavage.

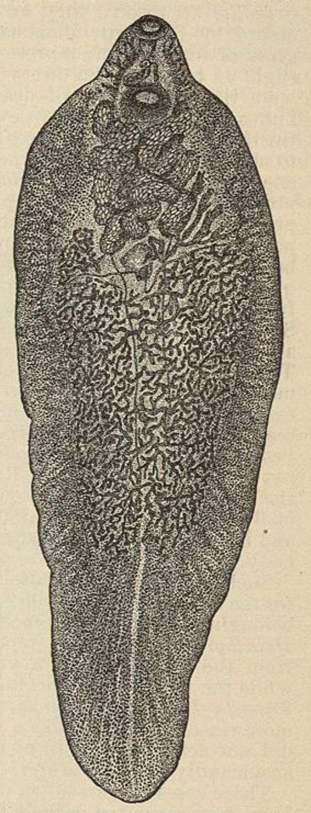
Fig. 4779.—*Fasciola hepatica* (L.). American Specimen from Cattle. Magnified. (After Stiles.)

This species is parasitic in the biliary ducts of sheep especially, but it also occurs in many other ruminants, cattle, goat, horse, ass, deer, antelope, camel, as well as in the kangaroo, squirrel, beaver, 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 eggs must remain some weeks in water at the ordinary temperature to complete the development of the miracidium, which on being set free seeks out a small snail (*Limnæa 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 fleshy region 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 rediæ, which remain in the same host, and sometimes give rise to a second generation of rediæ (Fig. 4777, *A*, *B*). The cercariæ (Fig. 4777, *C*, and Fig. 4778), which are produced by rediæ 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 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 infection of the final 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 excrement of the sheep. Lutz found that in the Hawaiian Islands *Limnæa oahuensis* and *L. rubella* 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; it 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