ARTICLE IV.—*On the Anatomy and Histology of a New Earthworm* (*Diplocardia communis*, gen. et sp. nov.). By H. GARMAN.

CHARACTERS OF THE GENUS.

Vasa deferentia opening to the exterior behind the clitellus by two apertures on the ventral side of somite 19. Two copulatory fossæ extend from the middle of the ventral side of somite 18 to the middle of the ventral side of somite 20, each fossa with a pair of long, curved setæ and an outlet of a prostate gland at its extremities. Internal apertures of the vasa deferentia two pairs; one pair in each of the somites 10 and 11. Seminal vesicles in somites 9, ?10, and ?11. Testes in somite 12. Spermathecæ in three pairs, one pair in each of the somites 7, 8, and 9. Ovaries flabelliform, situated in somite 13. Internal apertures of oviducts in somite 13; external apertures in somite 14. Setæ arranged in four double longitudinal series on the ventral side of the body, each somite bearing four pairs. Œsophagus very short, without calciferous glands. A muscular gizzard in somites 6 and 7. Typhlosole a very slight dorsal fold. Dorsal vessel double, consisting of two tubes fused only at the dissepiments. No subneural blood vessel present. Nephridia tubular, with the nephridiopores in line with the dorsal setæ of the external pairs; internal aperture in the somite preceding that in which the gland lies. Brain small, transversely elongated, with slight median anterior and posterior excisions. Præstomium not completely dividing the integument of the first somite.

The genus is based upon a large cylindrical flesh-colored species which is common in the black soil of Illinois prairie-land. Its body is made up of from 123 to 165 somites, and reaches a length of a foot. The following account of its anatomy will furnish the means of distinguishing it from other species of the genus which may be discovered.

The Form and Exterior.

The body is, for the greater part of its length, perfectly cylindrical in shape, there being none of the flattening of the posterior ventral region observable in species of Lumbricus. It increases gradually in diameter from the præstomium to somite 7, where it is thickest, then gradually diminishes to somite 11, posterior to which the diameter remains constant (not considering the clitellus) until a short distance from the posterior extremity, where it abruptly descends, the decrease being confined to about six very short terminal somites.

A few of the first somites are shorter than those which follow, but the maximum of length for these divisions of the body is reached at about somite 7; behind this somite is a gradual decrease in their length, so that at the middle of the length of the body somites are only half as long as the longest, and at the posterior extremity they are less than a third of the length of anterior somites. Impressed encircling lines divide the surface of the integument into numerous small false segments, and render the limits of the somites difficult to distinguish until the disposition of these lines is known. Somite 1 is without encircling lines, and its surface is plicated longitudinally. Somite 2 shows the plication on its anterior half, and also lacks the lines. The surface of 3 is devoid of wrinkles, but shows a single very faint encircling line. Somite 4 shows a distinct nearly median line and a faint anterior one. Somite 5, like most of those following, is encircled by two lines dividing its integument into three false segments, of which the median is smallest. Towards the posterior end of the body the lines disappear, about a dozen short terminal somites lacking them, and a few preceding these having a single one.

The mouth is a transverse slit, bounded below and at the sides by a fleshy lip — the anterior edge of somite 1 — and above by the præstomium. The latter is of the usual shape, has a perfectly smooth surface, and by its narrowed posterior portion reaches the middle of the dorsal wall of somite 1. Wrinkles sometimes continue its lateral boundaries and give it an appearance of completely dividing the integument of the first somite. The vent is terminal and vertical in position; the integument about it is faintly plicated.

The Setæ.

Four double longitudinal rows of setæ with distances between adjacent rows nearly equal, are disposed along the ventral face of the body. Each ordinary somite, therefore, bears eight setæ in four pairs. In sections, the two inner pairs of setæ are seen to be a little farther apart than each inner pair is from the outer pair of the same side. A line drawn through the middle of a somite at right angles to its vertical axis, would touch at its extremities the outermost seta of both outer pairs. The setæ are thus confined to the ventral half of the body. Setæ are lacking upon somite 1 and upon the three or four terminal posterior somites. They are of the usual form, but are rather slender. The distal extremity is bent a very little, and is obtusely pointed; the proximal end is bluntly rounded; the angulate swelling at the proximate end of the distal third is inconspicuous. In place of the inner pairs of ordinary setæ, on somites 18 and 20 are pairs of long uniformly curved copulatory setæ. On somite 19 the two inner pairs of setæ are lacking.

The Dorsal Pores.

The first dorsal pore is situated between somites 10 and 11. These openings are elliptical in outline, and are transversely placed. They may be obliterated in alcoholic specimens by the contraction of surrounding tissues, but in worms killed in corrosive sublimate they can be readily studied.

The Clitellus.

The clitellus does not appear until the worms are nearly grown, when the somites which will eventually bear the glands assume a dull yellow color, but are not swollen beyond the common outline. In large examples collected during the month of May the clitellus is well developed. It is of a pale flesh color, projects beyond the common outline a little, and occupies the walls of somites 13 to 18 inclusive. Its surface often presents peculiar fissures, which appear as if made by passing the edge of a knife blade over it; the encircling rings

are obliterated on the gland-bearing somites. In some cases the gland is developed only on the posterior part of the wall of somite 13, and it is generally less developed on this somite than on those which succeed it. It is not developed over a narrow median ventral area between the two inner rows of setæ. The lateral edges of this area are sinuous, from ingrowths of the gland between each two pairs of setæ. The area begins to widen towards the front on somite 14, and towards the rear on somite 17.

The External Apertures of the Genital Organs.

The external apertures of the three pairs of spermathecæ show very clearly in examples killed in corrosive sublimate, at the anterior edges of somites 7, 8, and 9, opposite the interspaces between the setæ of inner pairs on the same somites. The openings are upon minute transversely-placed prominences.

The external apertures of the oviducts are two minute pores, very close together, within and a little in advance of the two inner pairs of setæ on the ventral side of somite 14. In many examples the surrounding integument is a little elevated, producing a low transversely-elongated mound bearing the apertures at its summit.

Two copulatory papillæ are usually present on the posterior edges of somites 17 and 20, one opposite each inner pair of setæ of these somites. In most cases these are the only papillæ present; but in one example seen, there were besides the pair on somite 17, four pairs on somites 20, 21, 22, and 23, respectively. In still other examples a pair was found on each of somites 16, 17, 20, and 21.

At about the middle of somite 18, at the points at which the pairs of copulatory setæ appear, are the anterior ends of two shallow copulatory fossæ shaped like parentheses, but with the convex sides towards each other. These grooves extend across somite 19 and terminate on somite 20, where also copulatory setæ appear. No apertures of sexual organs can, by ordinary means, be perceived in this region; but on cutting out the body-wall and studying it with a microscope, the aperture of the duct of a prostate gland will be found in the two extremities

of each fossa, one opening, thus, beside each pair of copulatory setæ on somites 18 and 20. The vasa deferentia open on two very small papillæ, one in each fossa near the middle of somite 19. The vasa are in no way connected with the prostate glands. Between the fossæ the body-wall is a little impressed, and forms here a shallow basin.

The Dissepiments.

No dissepiments are present, apparently, between the four most anterior somites. The first developed partition separates somites 5 and 6. It is much thinner than the five succeeding ones. The latter are greatly thickened from the unusual development within them of muscle fibers. These six anterior dissepiments, and to some extent those immediately following, project backwards from the line of attachment to the body-wall, so that anterior septa are received into succeeding ones, and the part of the alimentary canal belonging in one somite may be carried back into another. Cross sections from this region are sometimes puzzling on account of this. Posteriorly the dissepiments grow thinner and more transparent from loss of their muscular character, and in the greater part of the body are reduced to delicate films. The aperture in each septum beneath the alimentary canal is circular in outline, and reaches from the ventral side of the canal to the body-wall. Through these apertures pass the ventral blood vessel and the ventral chain of nerve ganglia.

The Alimentary Canal.

The pharynx extends from the mouth to about the beginning of the fourth somite. It is of the usual character, consisting of a thin-walled sac with numerous bands of muscle extending from its outer surface backwards and outwards to the body-wall. When it is empty, its walls are extensively infolded, producing an irregular longitudinal plication of its inner surface.

At the posterior end of the pharynx, the dorsal wall of the canal presents a narrow transverse inward fold. Behind the fold the caliber abruptly increases again with no change in the

character of the walls. This region of the canal is the only part that can be considered an œsophagus. The exterior is devoid of muscular bands and the walls are thin and distensible. There is no trace of calciferous glands. The œsophagus, if such it can be termed, is ordinarily crowded into a very narrow space and on casual observation may escape notice as a division of the canal. It may be doubled over the next division.

Within somites 6 and 7 the walls of the canal become greatly thickened by a development of circularly arranged muscle, and form a powerful grinding apparatus,—the gizzard. Exteriorly this region is noticeable from its pearly lustre and unyielding walls. It really consists of two divisions, belonging in somites 5 and 6, respectively, but the backward extension of the septa brings the anterior part within 6 and the posterior part within 7. The line of attachment to its wall of the septum between 5 and 6 indicates the line of separation of the two divisions. This separation is narrow but complete, the wall of the intervening region being thin, and lacking the circular muscle fibers. Longitudinal sections of the gizzard show each part to consist of a zone of muscle which is thickest at its middle, and diminishes in thickness, somewhat, anteriorly and posteriorly. The anterior division of the gizzard is the larger; both divisions decrease a trifle in diameter from before backwards.

The first division of the intestine is the most slender portion of the alimentary canal. It is cylindrical, with smooth and rather firm walls, with a gradually increasing development of chloragogue cells from before backwards, the posterior third becoming dark brown in color from the abundance of these cells. It extends from the gizzard to somite 17, terminating after passing through the partition between 16 and 17. The epithelial lining of this division of the intestine is closely corrugated.

Within the posterior part of somite 17 the canal at once expands, loses the chloragogue cells, and becomes thin-walled. This forms the beginning of a second division of the intestine, the largest in caliber of all, extending through somites 18 and 19 and terminating in somite 20, where begins the third division.

The third division of the intestine extends from somite 20 nearly to the posterior end of the body. It is similar to the preceding more inflated part, being thin-walled and sacculated, and is pretty uniform in diameter throughout.

Towards the vent the canal again changes in character to form the rectum. Exteriorly there is little to distinguish this division from the intestine which precedes it, but cross sections show a decided thickening of the wall, due to an increase of muscle tissue and to the great development of the lining epithelium.

No intestinal cœca have been observed.

The typhlosole might easily escape observation on casual study. It is represented by a low ridge projecting into the cavity of the intestine from the dorsal side and extending from somite 23 backwards. It begins to decrease in size behind somite 40, and soon becomes scarcely perceptible.

The Vascular System.

The vascular system of this genus differs from that of Lumbricus in being simpler,—the subneural vessel and the commissural vessels putting the latter in communication with the dorsal vessel being here wanting. With certain of the postclitellian group of genera, Diplocardia shows marks of closer relation with respect to these vessels.

The dorsal vessel is distributed upon the pharynx in the usual manner. From the pharynx it extends backwards over the gizzard as a simple tube without branches until just before the dissepiment between somites 6 and 7, where very small lateral branches pass around the posterior part of the gizzard and enter the subintestinal vessel below. Immediately behind the dissepiment between somites 6 and 7, the dorsal vessel divides into two trunks, which again unite to pass through the dissepiment between somites 7 and 8. In somites 8 and 9 the same thing occurs, accompanied by an increase in the size of the dorsal vessel and its lateral branches. In somites 10, 11, and 12 the lateral branches become greatly enlarged, equaling in diameter the dorsal vessel in these somites. All these "aortæ" are loosely bound to the posterior septa of the somites in which

they lie, by very thin mesenteries. They are not closely bound to the intestine, as sometimes represented in figures of other earthworms, but give abundant space within for the distension of the intestine with food, and are therefore not themselves liable to be disturbed by the operations of digestion. Posterior to somite 9, the divisions of the dorsal vessel are not widely separated as they are in somites 7, 8, and 9; but the double character persists, and cross sections show that there are two completely separate tubes, at least at the middle of the somites, throughout the remainder of the body. Possibly in some cases the tubes do not unite to pass through the septa, since the channel between them may reach the septum and seem to continue the division through it. The dorsal vessel reaches its maximum diameter in somite 14. Anterior to this somite the vessel gradually decreases in size; posterior to it the vessel is for some distance about equal in size to the anterior division of the intestine, which it overlies and conceals. In somites 14–19 there is a sudden increase in the size of the vessel. Posterior to somite 19 the vessel is a little smaller, and continues quite uniform in diameter (with a very gradual decrease in size) to its termination at the posterior end of the body. In somite 13 the walls of the vessel show a few chloragogue cells when examined with a hand lens. Anterior to this somite the vessel is devoid of this gland. Posterior to somite 13 the vessel is thickly coated with the cells.

No free lateral branches are given off from the dorsal vessel in somite 13, but in all the somites following, two slender, contorted lateral branches pass off, one on each side, just before the posterior septum, and, like the aortæ, are bound to the dissepiment by a delicate mesentery. The pair in somite 14 reach the body-wall between the outer and inner pairs of setæ, and without branches pass into the integument. Those in succeeding somites divide into several branches just before reaching the body-wall, some of which doubtless collect the blood from the segmental organs and other structures, but most of them seem to emerge from the integument. In living worms the branches in adjacent somites may be seen to anastomose with each other and to ramify extensively in the body-wall. A vessel of unusual size collects blood from the clitellus

and joins the lateral vessel of each side in somite 18. All these lateral branches are, like the posterior part of the dorsal vessel, thickly covered with the brown chloragogue cells up to the point at which they pass into the body-wall. They are highly elastic, and after being stretched forward to their full extent during systole of the portion of the dorsal vessel to which they are attached, at once become contorted, or partly coiled, when the dorsal vessel again relaxes. The relatively thick chloragogue coating renders them conspicuous objects, although the blood vessel proper is generally very small. From first to last they are free from the alimentary canal.

The minute gastric branches reach the dorsal vessel a little before the middle of each somite. A close capillary network may be seen in the walls of the intestine, which in some of the anterior somites assumes the form of longitudinal sinuses.

The subintestinal blood vessel is slung by a mesentery from the ventral median line of the alimentary canal, and lies above the ventral nerve chain, passing along the dorsal side of the apertures in the dissepiments. By the dissepiments it is at regular intervals held near the ventral median line of the body, but in the cavities of the somites lies free in wide loops which extend from side to side. A pair of branches is given off before each dissepiment. It is smaller than the dorsal vessel, consists of a single tube, is non-contractile, and is not coated with chloragogue cells.

The Genital Organs.

Three pairs of spermathecæ are present in Diplocardia. They occur in somites 7, 8, and 9, increasing a little in size from before, are pyriform in shape, with corrugated outer surface when not distended with spermatozoa, and each sends a rather thick duct through the body-wall, near the anterior septum, opening, as has already been noted, opposite the inner pairs of setæ. Each sac is provided with a small reniform cœcum, closely attached to one side at the point at which the duct leaves the receptacle. They are rather large, sometimes extending up along the sides well towards the dorsal vessel.

The shape of the cœcum varies occasionally, and may be cut up into irregular lobes. Quite frequently the receptacles are carried through the aperture in the lower part of a septum, and appear in a somite to which they do not belong.

Attached to the anterior face of the dissepiment, between somites 9 and 10, is a large, white, irregularly-lobed mass on each side of the alimentary canal,—the seminal vesicles. No lobes or ducts from these vesicles, passing through the septum, have been found, and no means of communication between the vesicles and the other male genital organs have been noted. It is possible, however, that in some conditions of these organs such lobes or ducts may exist, or, possibly, such communication may be by means of pores through the dissepiment. In worms more than half grown somites 10 and 11 are always found loosely filled with spermatozoa. These loose masses may have an extremely delicate membranous covering and represent lobes of the seminal vesicles, but no trace of such membrane has been seen either in sections or by the ordinary means; and it seems safe to assume that these somites are used simply as reservoirs for the temporary storage of the male element. In somite 12, on each side of the intestine, is a large white mass consisting of numerous berry-like lobes, the whole attached by a small area to the posterior side of the dissepiment between somites 11 and 12. Often they embrace the intestine and meet above it. These have been regarded as the testes because an examination of their contents shows them to contain the spermatozoa in various stages of development. No means of communication between these bodies and the somites in front of them has been observed, but doubtless the matured product is discharged through the septum to which the testes are attached. The spermatozoa are certainly not set free in the cavity of the somite in which the testes lie.

The vasa deferentia receive the spermatozoa by two pairs of large flared openings, one each in somites 10 and 11. They lie upon the floor of the somites, within the nephridia, one on each side of the nerve ganglia. The vasa deferentia, passing from them, at once plunge into the integument and become embedded in the thick inner layer of muscle of the body-wall. The vasa of each side soon meet, and thence continue side by

side towards the outlet in somite 19. They lie just outside the outer seta of the inner pair, are perfectly cylindrical, a little contorted, and gradually approach the exterior, so that at the point at which the ducts of the first pair of prostate glands pass to the exterior, the vasa are at the middle of the muscular layer in which they are embedded. Just before turning outwards to their outlet in somite 19, they unite, and thus open by a single duct in the copulatory fossa, as already noted. From their position in the muscle layer, they cannot be traced by the methods of ordinary dissection, and it was only by cutting serial sections that they were finally traced to the external outlets.

Four peculiar glands, doubtless the homologues of what have been named *prostate glands* in other genera of Oligochæta, still remain to be described as a part of the male reproductive apparatus. In Diplocardia they have no direct connection with the vasa deferentia, but the products of both are discharged into the copulatory fossæ, and thus the same result is probably attained as would be by the passage of the vasa into the glands. Each gland opens by a separate duct at one end of a fossa. The glands are long, strap-shaped, orange-yellow bodies, floating for the greater part of their length free in the somatic fluid, so that they often pass by the apertures of the dissepiments into somites other than those in which they belong. They are abruptly bent where attached to the floor of the somites in which they open, and a large muscular duct arises near this end of the gland and penetrates the integument to the exterior. Each duct is accompanied by a pair of long copulatory setæ, occupying the place of the inner pairs in somites 18 and 20.

Excepting the form of the ovaries, the female genital organs of this genus are not especially different from those of Lumbricus. The ovaries are attached to the posterior face of the septum, between somites 12 and 13, and thus lie in the latter division of the body. They consist of rather large fan-like sheets of tissue, narrowing to a thick pedicel by which they are fastened to the septum, and under the microscope are seen to be made up of numerous parallel series of ova, growing more and more mature towards the free edges of

the sheets. The whole structure is folded upon itself in an irregular fashion, and its free edges may be very ragged from the tearing apart of the extremities of series of ova.

The oviducts may be found posterior to and opposite the ovaries in somite 13. Their free internal portions are trumpet-shaped structures having, when under the microscope, the appearance of a miniature calla lily. Behind the flared internal aperture the ducts are narrowed, and, passing through the dissepiment between somites 13 and 14, penetrate the body-wall in the anterior part of somite 14.

The Nervous System.

The cerebral nervous mass is very small as compared with that of Lumbricus and Allolobophora, and is correspondingly simple. It lies upon the pharynx, in somite 2, and is a slender, transversely elongated body, with a slight median anterior and and posterior impressed line of division between the two fused ganglia composing it. Its greatest diameter is less than a fourth of its length. As it lies in position it forms an arch, with the convex side posterior. Its surface is perfectly smooth, and no nerves arise from it except two large cords which supply the region about the mouth and arise one at each of its outer extremities. Numerous small white cords which are liable to be mistaken for nerves arise from its dorsal and ventral posterior surfaces, and extend posteriorly towards the skin, but their iridescence in sunlight shows them to be small bands of muscle.

Strong commissures extend obliquely down the sides of the pharynx from the extremities of the brain to the sub-pharyngeal ganglia in somite 3. A little ventrad of the brain each commissure gives off from its anterior edge a large nerve which extends forwards along the pharynx, parallel with the nerve arising from the extremity of the brain. Two other small cords also arise from the anterior edge of each commissure; one near the ventral end of the dorsal third of its length, the other near the dorsal end of the ventral third. The commissures gradually expand as they approach the first ventral nervous mass, their inner edges with the anterior edge of the

mass forming a gothic arch. From the expanded ventral part of each commissure is given off a fourth small nerve.

The first ventral nervous mass is depressed, and subtriangular in shape. Three large nerves arise from each side, and soon meet in one large strand. Their ultimate distribution has not been followed out. The ganglia posterior to the first are elongated elliptical, depressed masses, with strongly convex dorsal surface, and with no outward trace of division into two masses. The portions of the chain between the masses are very short, and show a slight median longitudinal impression as the only indication of a division into two cords. As the somites shorten towards the posterior end of the body, the nervous masses also become less elongated, and at the same time are brought closer together, the chain in the posterior part of the body being finally a succession of rounded swellings, with no interspaces. In the anterior somites each mass gives off from near its middle two large nerves on each side. They are directed forward and outward, and by large branches penetrate the body-wall. Other branches given off from them doubtless supply the viscera. Near the anterior limit of each mass a small nerve passes outward and forward on each side to the anterior dissepiment of the somite in which the mass lies. Ganglia forming the posterior part of the chain give off only one pair of nerves. The posterior mass (possibly representing several fused pairs of ganglia) gives off three pairs of nerves. From its middle pass out the two ordinary nerves. Posterior to these the mass becomes narrowed and gives off two small nerves, which extend outward and backward. From its posterior extremity a third pair of large nerves diverge and extend backward toward the integument in the region of the vent.

The Nephridia.

A pair of tubular segmental organs, similar to those of Lumbricus, occurs in most of the somites of the body. The internal apertures of these organs are in line with the outer setæ of the inner pairs, each aperture appearing in the somite preceding that in which its gland lies. The tube which passes through the septum from the aperture is small at

first, but rapidly increases in diameter, and passes outwards and upwards along the inside of the body-wall. Outside the outer pair of setæ the tube is abruptly bent and returns upon its course until within the outer setæ; then turns outwards again and extends about half as far as in the first loop; returns again upon its course; and finally, as a slender tube, passes down within the mesentery which holds the gland to the body-wall, and reaches the latter in front of the dorsal seta of the outer pair. In specimens prepared according to Semper's "dry method," the nephridiopores show very clearly at the anterior edge of each somite, in line with the outer setæ. There seem to be no pores in somites 1 and 2.

All the specimens of Diplocardia thus far examined have shown the external apertures of the vasa deferentia on somite 19, and hence behind the clitellus. If we follow M. Perrier's classification rigidly, we must, therefore, place this genus in the group *post-clitelliani*. The position of the male pores so near the posterior limits of the gland would seem to indicate an intermediate position for the genus, and other features of its anatomy apparently confirm this impression by pointing to relations with genera in both the divisions *intra*-and *post-clitelliani*. Thus, of the fourteen characters of the genus Microchæta, one of the *intra-clitelliani*, given by Mr. W. B. Benham,* five (2, 4, 6, 10, and 14) are, in essentials, common to the two genera, while as many more points of likeness could be selected which as clearly indicate a relation of the genera. M. Perrier's genus Anteus, another of the *intra-clitelliani,* also bears some resemblance to Diplocardia. In both, the nephridiopores are in a line with the dorsal seta of the outer pair; the anterior septa are thick and muscular; the setæ are disposed in four double, longitudinal rows, and the gizzard is anterior in position. Recognizing M. Perrier's divisions as good, we may consider these resemblances to indicate an inferior position for our genus. The lower forms of a group often combine in themselves characters distributed in a number of higher forms, and this we may suppose to be the case with Diplocardia. At

* Quart. Jour. Micr. Sci., N. Ser., No. CII., 1886, p. 291.

any rate its double heart, simple nervous system, the absence of a subneural blood vessel, together with its sluggish habit, mark Diplocardia as of low rank, and give us additional reason for placing it in the lowest of the three recognized groups.*

The two genera of *post-clitelliani* with which Diplocardia has most in common are Acanthodrilus and Digaster, belonging to Dr. Claus's family Acanthodrilidæ. With Acanthodrilus the genus here described agrees in the position of the nephridiopore, in the possession of four groups of modified setæ, in having four prostate glands, in the character and forward position of the gizzard, and in the character of the spermathecæ.

Of the three species upon which M. Perrier based the genus Acanthodrilus he says: "Leur caractère le plus saillant, celui qui frappe tout d'abord, c'est l'existence de quatre orifices génitaux mâles au lieu de deux. Par chacun de ces orifices, on voit sailler un faisceau de soies courbes, d'aspect nacré, tres-longues et plus ou moins rétractiles, sans l'etre toutefois d'une manière complète. Chacun de ses faisceaux constitue un véritable pénis." In Diplocardia there are only two external openings for the sperm ducts, and these are not upon the somites upon which the pairs of prostates open (18 and 20), but upon the intermediate somite (19). They do not pass into the prostates and discharge the sperm through the ducts of the latter, but can be traced from the somites in the anterior region of the body, where they open into the body cavity as two separate tubes, lying side by side in the inner muscle layer of the body-wall until just at the external aperture, where they unite in one tube. The apertures are not accompanied by setæ of any kind, the inner pairs of setæ being wanting on somite 19. At the apertures of the ducts from the prostate glands on somites 18 and 20 are long, gently and uniformly curved setæ, one *pair* for each of these ducts. They occupy the position ordinarily occupied by inner pairs of setæ, lie close together, are perfectly smooth, very slender, and are capable of complete

* In some of its characters it approaches the aquatic *Oligochæta limicolæ*. Eisen's Californian genus, Ocnerodrilus, is like it in the separation of the two vasa deferentia of each side until the external aperture is reached. Criodrilus approaches it in having an incompletely double dorsal vessel.

retraction, no trace of them being commonly perceptible from without. These probably represent the modified setæ of the prostate glands in Acanthodrilus, in which genus they are described as projecting fasicles of ornamented and more or less retractile setæ. The muscular duct of the prostate, with its accompanying setæ, does not, therefore, as in Acanthodrilus, constitute "un véritable pénis," the secretion of the prostates being in Diplocardia discharged independently of that of the seminal vesicles. This complete separation of the two sets of glands calls for another arrangement by which the secretions may be mingled, and this we have in the copulatory fossæ and the relations of the apertures of the various ducts to them. (See figure.) Another difference between the two genera is in the number of spermathecæ: Diplocardia has three pairs, one each in somites 7, 8, and 9, while Acanthodrilus has two pairs, one each in somites 8 and 9. With regard to the subneural blood vessel of earthworms, Mr. W. B. Benham (loc. cit.) says, "There is a sub-neural trunk in all forms, except Perichæta, Pleurochæta, Pontodrilus [and Microchæta]." From this we must infer that Acanthodrilus possesses this trunk; but in Diplocardia it is wanting, as are also the supraneural vessels. In the imperfect œsophagus of Diplocardia we may perhaps find still another differerence. This division of the alimentary canal is represented in Mr. Beddard's figure of *Acanthodrilus layardi* as a slender tube rather longer than the pharynx. It is represented as longer than the pharynx also in M. Perrier's *A. ungulatus*. Finally, the two genera differ in the character of the dorsal vessel. Some species of Acanthodrilus have been described as having the dorsal trunk divided in a few of the anterior somites, but in no description which I have seen has mention been made of a dorsal vessel made up of two tubes throughout its length, as in the case in the genus here described. Notwithstanding these differences, Diplocardia seems to the writer to be more closely related to Acanthodrilus than to Digaster. The position of the nephridiopores opposite the inner pairs of setæ, and the two muscular gizzards in the latter genus, render it very distinct from either of the others, and makes a comparison with Diplocardia unnecessary. The species of Acanthodrilus have been obtained from the East India Islands, from Madagascar,

and from South Africa. It is a matter of some interest, therefore, to find in this part of the world a genus bearing marks of close relation.

Thus far a single species has been seen. It is rather common in Illinois, generally occurring in soil, although occasionally found associated with species of Allolobophora in the compost heaps of gardeners. It is apparently not at home in the latter situation, and the large examples are almost always taken in damp soil, where they probably breed. It is sometimes common in lawns, and after protracted rains may be secured in considerable numbers along walks, where it has been belated during its nocturnal wanderings. Its burrows extend for some depth into the soil, and, like Lumbricus, it excavates, during droughts, a chamber at the bottom of its burrow, where it remains coiled up and perhaps inactive. Beyond this, little is known of its habits.

With regard to its distribution outside the State nothing positive can be said at present, but the writer is disposed to believe that he has seen this or a similar worm in the Eastern States. Within the State it is generally distributed, and will probably be found to occur in other states in the Mississippi Valley.

Notes on the Histology.

In the course of attempts to stain examples of Diplocardia for section cutting, a surprising difference between it and the genus Allolobophora becomes apparent. Allolobophora stains well in Grenacher's borax carmine preparation, the nuclei of all the tissues being brought out with the stain in a very satisfactory way. Diplocardia, on the contrary, does not stain well in this fluid, the result generally obtained with it being a diffuse color, with the nuclei of muscle and connective tissue poorly differentiated. The results were not due to any difference in the method of killing or preservation, for specimens of the two genera killed and preserved at the same time and in the same way gave this difference, and proved it to be due to something in the tissues themselves. Just what this something is we are not prepared to state, but the manner in which the tissues

respond to the stain would seem to indicate a difference in the chemical or physical properties of the tissues of the two genera, — a difference hardly compatible, the writer thinks, with any very close relation of the worms.

The muscle fibers in the longitudinal layer of the body-wall are irregularly disposed (Figs. 13, 16, 17), and cross sections show nothing of the double series so characteristic of this layer in Lumbricus. With this exception there seems to be no essential difference between Diplocardia and Lumbricus with respect to the muscular system. The layers of the body-wall have about the same thickness relative to each other in both genera. Measurement of the body-wall beneath the nerve cord in the anterior part of the body of a Diplocardia of medium size gave a diameter of .40 mm., of which the cuticle and hypodermis together equaled .05 mm., the circular muscle layer .09 mm., and the longitudinal muscle layer .26 mm. In the greater part of the wall of the alimentary canal the muscular tissue is not very conspicuous. In the gizzard, of course, it is greatly in excess of other tissues. (See Fig. 10.) In the rectum, also, the muscular layers become prominent. Measurements of the anterior portion of the rectum gave a thickness of .05 mm. each for the epithelium and circular muscle layer, and about .02 mm. for the longitudinal layer. Near the vent there is a still further increase in all the tissues, measurement giving for the epithelium a diameter of .15 mm., for the circular muscle layer .10 mm., and for the longitudinal layer .05 mm. Everywhere the muscle fibers are bound together by connective tissue, which, in the body-wall, forms, in places, layers of some thickness; but probably nothing comparable to the "bundles" of vertebrate muscle exists.

Cross sections of muscles present a good deal of variation in the size and shape of fibers. Some of this is due to the state of contraction in which the fibers are fixed by reagents; but there is still variation in size not to be accounted for in this way, and probably indicating a real difference in the size of fibers. Sections may be .008–.012 mm. in longer diameter by .004 mm. in shorter diameter. The ribbon-shaped fibrils of which the fibers are largely made up, are ranged in series extending with the longer diameter of the fiber, giving to

sections the appearance of cross striation. In the small fibers they seem to form a single continuous series, the individual fibril being wider or narrower according to the part of the fiber it occupies. But in large fibers the fibrils reach across the shorter diameter only at the ends of the series, and medially form two series, one at each edge, with a central space between them, as if fibrils of a single series had been broken at the middle and the two series thus formed were slightly parted. Upon tearing apart the elements of stained fibers an interstitial granular protoplasm becomes apparent, adhering to the surfaces of fibrils in shreds and deeply-stained knots.

Longitudinal vertical sections of the brain show the latter to be slightly depressed at the sides, where the sections are elliptical in contour. Medially the brain is less flattened. The fibrillar central tissue is surrounded everywhere, except anteriorly and along the ventral middle line, by numerous rather small unipolar nerve cells of the usual structure. Certain of the anterior cells, above and below, are larger than the others and occupy a depression in the fibrillar substance. The nervous tissue is invested and protected by fibrous connective tissue, the nuclei of which are scattered among the nerve cells and occur between the divisions of the fibrillar nervous matter. Outside this investing material is a moderately thick sheath, in which may be distinguished numerous blood vessels, connective tissue, and a highly refracting granular material, the nature of which has not been determined. Upon the posterior surfaces, dorsal and ventral, the bands of muscle referred to in another part of this paper can be seen, the larger bands consisting of about three fibers. Excepting these bands there seems to be no muscular tissue in the brain sheath. The sheath covering the dorsal side of the brain has a very sharply-defined inner boundary consisting of a membrane, apparently of homogeneous matter and probably a modified connective tissue. There is some appearance of such a membrane at the ventral side, but it is here much less distinct. The outer limits of the sheath are not well defined. The commissures between the cerebral and sub-œsophageal ganglia are enclosed in a thin sheath, in which may be seen the same refracting granules as are found in the brain sheath. No muscular tissue is present, apparently.

The sheath of the ventral nerve chain has a well-defined outer and inner limiting membrane of modified connective tissue, similar to that described for the cerebral ganglion. From the inner one, in some sections, fibers may be seen passing in among the other tissues of the sheath, while occasional strands of connective tissue extend from it across the cord, at the sides of the median giant fiber, to the membrane of the opposite side of the cord. The sheath is not as thick on the first ventral mass as it becomes farther to the rear, and it lacks here the muscle fibers, most of its substance being made up of granular matter and of blood capillaries. The muscular tissue of the sheath appears between the first and second ganglia, and shows on ganglion 2 as a series of fibers next the inner enclosing membrane of the sheath, the sheath being still made up largely of the refracting granular material. Beneath the slender anterior division of the intestine the muscular tissue of the nerve cord becomes better developed, the fibers being large and not so closely confined to the inner membrane of the sheath. In the region of somites 19 and 20 the sheath is largely made up of muscle. (Fig. 19, Pl. IV.) The fibers of this muscle have exactly the same structure as those in the body-wall, consisting of series of flattened fibrils, with central space and interstitial protoplasmic substance. The sheath becomes thinner again posteriorly and loses much of its muscular character, the fibers appearing, as in front, as a series along the inner membrane of the sheath. (Fig. 21, Pl. IV.)

It seems evident that the function of these muscles of the nerve sheath is to adjust the cord to the very great changes in the length of the body of the worm, and to accommodate it to the abrupt bending of the body from side to side which occurs during the creeping and burrowing operations of the living worm. A sudden change in length from a foot to six inches requires that the nerve cord be, by some means, readily adjusted to so abrupt and pronounced a change without taking harm or having its office interfered with. The longitudinal muscle fibers of the sheath doubtless shorten the cord at such times and prevent its being thrown into folds. Sections of the cord from greatly shortened worms show an expanded condition, probably attributable to

this action of the muscles. These sections may be circular in outline, while sections from worms killed in an extended condition are transversely elliptical.

Within the sheath of the ventral cord, connective tissue, giant fibers, nerve cells, and fibrillar nervous tissue are arranged as they are in Lumbricus and Allolobophora. The nerve cells occupy the lateral and ventral space within the sheath, and lie in little hollows in the connective tissue, with their contracted ends converging towards the points at which their fibers pass into the central nervous tissue. Most of the fibers from cells reach this tissue at the middle of the outside of the mass, and in sections are seen in a cluster about this region. Another set sends fibers into the inner ventral side of each half of the fibrillar tissue. (Pl. IV., Fig. 21.) The cells are thickly placed along the swellings, but become less abundant as the commissures are neared, and in the intervals between ganglia are completely lacking for a short distance.

The central substance of the nerve chain is seen, in cross sections, as two lightly staining areas, chiefly granular or fibrillar, apparently according to the reagents through which the tissue has been passed. At the center of the swellings this matter fuses across the middle line below the giant fibers. Elsewhere the substance of each side remains separate, with the intervening space occupied by fibrous connective tissue.

The giant fibers are three in number, as in Lumbricus and Allolobophora, and occupy the same position relative to the other parts of the cord as in these genera. They do not appear in the subœsophageal ganglion, but in the interval between this and the succeeding mass the median fiber appears abruptly, while the two smaller lateral fibers appear some distance further to the rear. In the region of the eighth or ninth somite the lateral fibers become clearly visible, but are not yet half the diameter of the median fiber. At the extreme posterior end of the cord the giant fibers are lacking, but beneath the rectum the three are of equal size, the lateral fibers having gradually increased in diameter from before backward. The connective tissue completely invests the fibers which lie in the ganglia in a series just within the sheath of the cord and chiefly above the central nervous substance. They do not vary

with the cord in diameter, and to accomodate them to the diminished size of the cord between ganglia the median fiber is there brought down between the divisions of the central nervous matter. Unlike these structures in Allolobophora, the giant fibers are in this worm provided with a thick and well-defined connective tissue sheath (Plate IV., Fig. 19, *a*) which isolates them from the surrounding connective tissue. The axis of each fiber is hollow, and in the living worm is filled with a semifluid matter which, in the sections of hardened tissue, is seen as a deeply staining granular residue, sometimes forming a film on the wall of the cavity, sometimes giving imperfect stellate transections, and, again, filling the whole space. The walls of the axial space are well-defined, and in many cross sections examined I have seen a ring of small discs about it, as if the wall were made up of small longitudinally disposed rods, the discs being their cross sections. Focusing on sections with high powers gives an appearance of fibers passing from this wall into the central space.* The fibers of the connective tissue sheath of the giant fibers seem to anastomose with those of the ordinary connective tissue of the nerve cord. The fibers of the sheath seem to join the "rods" immediately about the axial space. Nothing has been seen of the vertical septum mentioned by Dr. Leydig as dividing the cavity of the median fiber in Lumbricus, and no connection between the giant fibers and the nerve cells or central nervous tissue has been found.

As to the function of the giant fibers I am disposed to accept Vejdovsky's view, that they are supporting structures instead of parts of the nervous apparatus proper. Whether or not they can be considered homologues of the notochord of vertebrates must, it seems to me, be left until more has been done with the embryology of invertebrates. They probably originate with the sheath and connective tissue of the cord, and thus independently of the essential nervous tissues.†

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* See Dr. Leydig's note on the giant fibers of earthworms. (*Die riesigen Nervenröhren im Bauchmark der Ringelwürmer, Zool. Anz.*, 1886, p. 591.)

† Structures which resemble the giant fibers of earthworms are present in the ventral cord of Cambarus, and are said to occur also in

The columnar epithelial cells with which the alimentary canal is lined are, in a large part of the canal, indurated and united at their inner ends, and in the middle division of the intestine are densely and strongly ciliated.

Nothing of interest can be added to the published accounts of the hypodermis in related worms. Numerous gland cells of several forms occur with the more slender cells which make up the bulk of the layer. Toward the anterior and posterior extremities of the body the cells become gradually longer, and thus approach in character the epithelium of the stomodæum and proctodæum.

Sense organs in the form of small clusters of fusiform cells, bearing a close resemblance to the goblet-shaped organs of the skin of fishes and amphibians, are very abundant in the hypodermis about the ambulatory setæ.

Within the wall of the alimentary canal are developed extensive blood sinuses, the great extent of which was not suspected before the wall was studied by sections. In the large division of the intestine there is a considerable space between the intestinal epithelium and the circular muscle layer, which is filled with blood. Across this space stretch bands of connective tissue from the epithelium to the muscle layer. (Pl. III., Fig. 14.) In the small anterior division of the intestine, also, we find an extensive system of lacunæ in which the blood circulates, and is brought in contact with the lining epithelium of the canal. (Pl. III., Fig. 15.) It is in these spaces, doubtless, that the blood receives the food material secreted from the contents of the intestine.

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other arthropods. As seen in the above-named genus they lack the connective tissue sheath so conspicuously developed in Diplocardia, and owing to the more perfectly disparate character of the cord there is no place for a median fiber. They appear to be simply longitudinal channels in the connective tissue, and represent, perhaps, the axial part of the fibers of earthworms. These channels contain, in preserved tissues, a residue in which, in addition to the minute granules such as occur in the fibers of Allolobophora, there are scattered corpuscular bodies of larger size.

The appended account of North American earthworms has been drawn up largely from the works of Eisen, Rosa, and Uhde. Only the *oligochæta terricolæ* are given, and probably the list of these will prove far from complete when more attention has been given to collecting and studying our species. The *Lumbricus americanus*, Perrier (*Recherches pour servir l'histoire des Lumbriciens Terrestres*, p. 44), which is said by its describer to represent in New York the *L. terrestris* of Europe, is probably one of the species of Allolobophora of the list given below. The description of *L. apii*, Kinberg, from California, has not been seen.

I wish here to acknowledge indebtedness to Prof. Forbes for his kindness and liberality in the matter of special papers on Oligochæta, and to Messrs. McCluer and Weed, who have remembered me on several occasions with fine lots of living specimens.

FAMILY LUMBRICIDÆ.

Genus Tetragonurus, Eisen.

(Öfv. af K. Vet.-Akad. Förh., 1874, No. 2, p. 47.)

Prostomium only partly dividing the buccal somite. Outlets of vasa deferentia in somite 12. Intervals between the four double rows of setæ about equal. Body cylindrical anteriorly; quadrate in section posteriorly.

Tetragonurus pupa, Eisen.

T. pupa, Eisen, Öfv. af K. Vet.-Akad. Förh., 1874, No. 2, p. 47.

Somites 40. Clitellum on somites 18–22. Tubercula pubertatis on somites 19, 20, and 21. Length, 25 mm. Niagara, Canada (Eisen).

Genus Allolobophora, Eisen.

(Öfv. af K. Vet.-Akad. Förh., 1873, No. 8, p. 46.)

Prostomium not completely dividing the buccal somite. Outlets of vasa deferentia in somite 15. Setæ in pairs or separated.

Allolobophora bœckii, Eisen.

Lumbricus puter, Eisen, Öfv. af K. Vet.-Akad. Förh., 1870, p. 959.
Dendrobœna bœckii, Eisen, ib., 1873, No. 8, p. 53.
Allolobophora bœckii, Rosa, Lumbricidi del Piemonte, 1884, p. 48.

Setæ in four nearly equidistant rows, the dorsal interval a little the largest. Somites 80–95. Clitellum on somites 29–33. Tubercula pubertatis on somites 31, 32, and 33. Length of living examples, 30–40 mm. Newfoundland (Eisen).

Allolobophora riparia, Hoffm.

Lumbricus riparius, Hoffm., Arch. f. Naturg, 1843, p. 189.
Allolobophora chlorotica, Rosa, Lumbricida del Piemonte, 1884, p. 34.

Dorsal pores beginning between somites 3 and 4. Setæ of pairs close together. Somites 80–100. Tubercula pubertatis on somites 31, 33, and 35. Clitellum on somites 29–37. Length 50–80 mm. California (Eisen.)

Allolobophora fœtida, Savigny.

Enterion fœtidum, Sav., Cuv., Hist., des progr. des sc. nat., 1828, T. 4, p. 14.

Lumbricus olidus, Hoffm., De verm. quib. ad gen. Lumb,, 1842.

Allolobophora fœtida, Eisen, Öfv. af. K. Vet.-Akad. Förh., 1873, No. 8, p. 50.

Dorsal pores beginning before somite 7. Setæ of pairs close together. Somites 85–105. Tubercula pubertatis on somites 28, 29, 30, and 31. Clitellum on somites 25,* 27–32. Length 80 mm. Champaign, Ill., abundant.

Allolobophora subrubicunda, Eisen.

A subrubicunda, Eisen, Öfv. af. K. Vet.-Akad. Förh., 1873, No. 8, p. 51.

Dorsal pores beginning before somite 7. Intervals between setæ 1, 2, 3, and 4, about equal. Somites about 110. Tubercula pubertatis on somites 28, 29, and 30. Clitellum on somites 26–31. Length 90 mm. Niagara, Canada (Eisen).

Allolobophora mucosa, Eisen.

A. mucosa, Eisen, Öfv. af K. Vet.-Akad. Förh., 1873, No. 8, p. 47.

Lumbricus communis, Hoffm. (in part), Arten d. Regenw., 1845.

Dorsal pores beginning before somite 7. Setæ of pairs close together. Somites 130. Tubercula pubertatis on somites 29, 30, and 31. Clitellum on somites 25, 26–32. Length 50–70 mm. when alive and moderately extended. Champaign, Ill., frequent. New England (Eisen).

Allolobophora turgida, Eisen.

A turgida, Eisen, Öfv. af K. Vet.-Akad. Förh., 1873, No. 8, p. 47.

Lumbricus communis, Hoffm. (in part).

Dorsal pores beginning between somites 8 and 9. Setæ of pairs close together. Somites 104–240. Tubercula pubertatis on somites 31 and 33. Clitellum on somites 27, 28–34, sometimes 27, 28–35. Length 60–160 mm. Champaign, Ill., abundant; also received from North Carolina. New England and Canada (Eisen).

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*The numbers indicating the position of the clitellum are here used as in the descriptions of Eisen, the first number showing the degree to which the anterior portion of the clitellum may vary.

Allolobophora tenuis, Eisen.

A. tenuis, Eisen, Öfv. af K. Vet.-Akad, Förh, 1874, No. 2, p. 44.

Somites about 100. Clitellum on somites 25, 26–31. Tubercula pubertatis on somites 28 and 29. Length 50–60 mm. N. England, Canada, California (Eisen).

Allolobophora tumida, Eisen.

A. tumida, Eisen, Öfv. af K. Vet.-Akad. Förh., 1874, No. 2, p. 45.

Somites about 40. Clitellum on somites 21–28. Tubercula pubertatis on somites 26 and 27. Length about 30 mm. N. England (Eisen).

Allolobophora parva, Eisen.

A. parva, Eisen, Öfv. af K. Vet.-Akad. Förh., 1874, No. 2, p. 46.

Somites about 100. Clitellum on somites 23–29. Tubercula pubertatis on somites 24, 25, 26, 27, 28, and 29. Length about 40 mm. N. England (Eisen.)

Allolobophora nordenskioldii, Eisen.

A. nordenskioldii, Eisen, On the Oligochæta collected during the Swedish Arctic Expeditions in the years 1870, 1875, and 1876, p. 6.

Somites 80–125. Tubercula pubertatis on somites 28, 29, and 30. Length 80–150 mm. Closely allied to *A. fœtida*. Obtained by Eisen in Siberia; credited to North America by Vejdovsky.

Genus Lumbricus, Linné.

(Linné, Syst. Nat., 1735.)

Prostomium completely dividing the buccal somite. Outlets of vasa deferentia in somite 15. Setæ in pairs, four to each somite.

Lumbricus herculeus, Savigny.

Enterion herculeum, Sav.. Cuv., Hist. des progr. des sc. nat., II., p. 108, 1828.

Lumbricus terrestris, Linné, 1767.

Lumbricus agricola, Hoffm., 1842.

Somites 112–180. Clitellum on somites 32–37. Tubercula pubertatis on somites 33, 34, 35, 36. Length of living examples 150–300 mm., varying in alcohol, according to Rosa, from 90–150 mm. New England (Eisen).

Lumbricus rubellus, Hoffm.

Somites 95–150; bi- or triannulate. Clitellum on somites 26, 27–31, 32. Tubercula pubertatis on somites 28, 29, 30, 31. Length 70–120 mm. Newfoundland (Eisen).

Lumbricus purpureus, Eisen.

L. purpureus, Eisen, Öfv. af K. Vet.-Akad. Förh., 1870, No. 10, p. 956.

Somites 90, bi- or triannulate. Clitellum on somites 28–33. Tubercula pubertatis on somites 29, 30, 31, 32. Length of living worms 50–70 mm., of alcoholics 30–50 mm. Niagara, Canada (Eisen).

FAMILY ACANTHODRILIDÆ.

This family is represented by the genus Diplocardia, which has been described in the first division of this paper. Hundreds were seen this spring in this locality, migrating during showers of rain.

FAMILY PLUTELLIDÆ.

This family is represented by *Plutellus heteroporus*, described by Perrier, in 1873, from Pennsylvania. The following characters will serve to distinguish it from other worms: Setæ, eight in each somite, equidistant. Spermathecæ, a pair in each of somites 5, 6, 7, 8, and 9, each with a blind appendage. Entire nephridium in one somite, not extending through the anterior septum. External outlets of oviducts in somite 10, in line with inner setæ. External outlets of vasa deferentia in somite 18. Clitellum in somites 14, 15, 16 and 17. A "prostate gland" and penis present. Length 150 mm.

FAMILY PERICHÆTIDÆ.

A fine species of the genus Perichæta is becoming common in the hot-houses of the University, where it has probably been introduced with exotic plants. The numerous described species of this genus have been obtained chiefly from southeastern Asia, and, as far as I know, this is the first record of its occurrence in North America. I have not seen all the published

descriptions, and can not, therefore, determine it as to species.

The worm is noticeable among our forms from its active movements and extreme irritability. Body cylindrical, smooth, shining. Color, olive-brown, lighter below. Somites 110. Clitellum on somites 14, 15, and 16, constricted. External outlet of oviducts single, median, in a slight prominence on the ventral side of somite 14. Male outlets in two large ventro-lateral papillæ, one on each side of somite 18. Four pairs of spermathecæ a pair, opening at the anterior edge and ventral side of somites 6, 7, 8, and 9 respectively. Rings of setæ with a very slight median ventral hiatus, 48–55 in a ring, as counted in the anterior part of the body. Length 138–150 mm.

EXPLANATION OF THE FIGURES.

PLATE I.

FIG. 1.—Longitudinal vertical section through the anterior part of the body. *a*, Pharynx. *b*, Gizzard, showing the two thick bands of transversely disposed muscle of which its walls are largely composed. *c*, Œsophagus. *d*, Cerebral ganglion. *e*, Ventral nerve chain. *f*, Two of the thickened muscular septa.

FIG. 2.—Anterior part of the alimentary canal. *a*, Pharynx, with radiating bands of muscle. *b*, Gizzard. *c*, Œsophagus. *d*, Swollen beginning of intestine. *e*, "Prostate glands."

FIG. 3.—Anterior part of the dorsal vessel and part of the genital organs. *a*, Dorsal vessel. *b*, Two of the large "aortæ". *c*, One of the small contorted afferent blood vessels. *d*, Spermathecæ. *e*, Seminal vesicle (?). *f*, Testicle. *g*, Ovary. *h*, Oviduct.

PLATE II.

FIGS. 4–9.—Cross sections of the pharynx, showing the manner in which the dorsally situated tongue extends into the cavity of the pharynx. *a*, Pharynx. *b*, Nerve cord which supplies integument in region of prostomium. *c*, Tongue, appearing as a slight dorsal fold in Fig. 6. and becoming gradually larger and more muscular posteriorly, as in Fig. 9. *d*, Cerebral ganglion. *e*, Subpharyngeal ganglion.

FIG. 10.—Cross section of the muscular gizzard.

FIG. 11.—Dorsal view of the prostomium and the six anterior somites.

FIG. 12.—Ventral view of somites 13–20, showing the clitellum on somites 13–18. *a*, External aperture of the oviducts. *b*, One of the anterior copulatory papillæ. *c*, Copulatory setæ and aperture of "prostate gland". *d*, External aperture of vasa deferentia. *e*, One of the posterior copulatory papillæ.

PLATE III.

FIG. 13.—Cross section through the intestine. *a*, Dorsal vessel. *b*, Intestine. *c*, Typhlosole. *d*, Subintestinal blood vessel. *e*, Ventral nerve chain. *f*, Sections of small contorted afferent blood vessel. *g*, Cuticle of integument. *h*, Hypodermis. *i*, Circular muscle layer. *j*, Longitudinal muscle layer.

FIG. 14.—Part of the wall of the intestine greatly enlarged. *a*, Ciliated intestinal epithelium. *b*, Coagulated blood occupying sinuses between epithelium and circular muscle layer (*c*) of intestine. *d*, Longitudinal muscles of intestine. *e*, Bands of tissue extending across sinuses from epithelium to circular muscle layer. *f*, Connective tissue layer.

FIG. 15.— Cross section through œsophagus. *a*, Dorsal vessel. *b*, Œsophagus. *c*, Blood spaces in walls of œsophagus. *d*, Chloragogue layer.

FIG. 16.— Cross section of the body in the region of the rectum. *a*, Dorsal vessel. *b*, Rectum. *d*, Subintestinal blood vessel. *e*, ventral nerve cord.

PLATE IV.

FIG. 17.—Section of the body-wall passing through the ducts of the anterior "prostate glands." *a*, Sections of the embedded vasa deferentia. *b*, Ducts of the "prostate glands" passing to the exterior. *c*, Portions of the copulatory setæ. *d*, Ventral nerve cord. *e*, Longitudinal muscle layer of body-wall. *f*, Circular muscle layer of body-wall. *g*, Hypodermis.

FIG. 18.— *a*, Locomotor seta. *b*, Copulatory seta.

FIG. 19.— Cross section of the ventral nerve cord of anterior part of body, from between ganglia. *a*, Sheath of large median giant fiber. *b*, One of lateral giant fibers. *c*, Greatly developed muscular sheath of cord. *d*, Fibrillar nervous tissue invested with connective tissue. *e*, Axial substance of median giant fiber here drawn to one side.

FIG. 20.— Dorsal view of cerebral ganglion. *a*, Nerve which supplies region of prostomium. *b*, Commissure. *c*, Muscular bands arising from posterior side of ganglion.

FIG. 21.— Cross section of ventral nerve cord from posterior part of body through ganglion. *a*, Median giant fiber. *b*, Lateral giant fiber. *c*, Sheath of cord. *d*, Fibrillar nervous tissue. *e*, Unipolar nerve cells. *f*, Origin of lateral nerve.

FIG. 22.— Enlarged section of typhlosole and dorsal vessel, showing small intestinal vessel entering dorsal vessel at *b*. *a*, Left division of dorsal vessel. *c*, Dorsal vessel of right side, without intestinal branch (due to section not being true). *d*, Typhlosole.

PLATE V.

FIG. 23.— Ovary.

FIG. 24.— Oviduct.

FIG. 25.— Section of an ovum from the ovary. *a*, Investing connective tissue membrane (probably lost or resorbed when the egg is set free). *b*, Nuclei of connective tissue membrane. *c*, Nucleus of ovum. *d*, Nucleolus.

FIG. 26.— Spermatheca. *a*, Cœcum. *b*, Duct.

FIG. 27.— Copulatory fossa greatly enlarged. *a*, Fossa. *b*, Vasa deferentia, which unite near the external aperture at *c*. *d*, Aperture of "prostate glands". *e*, Copulatory setæ.

FIG. 28.— "Prostate gland". *a*, Duct.

PLATE I.

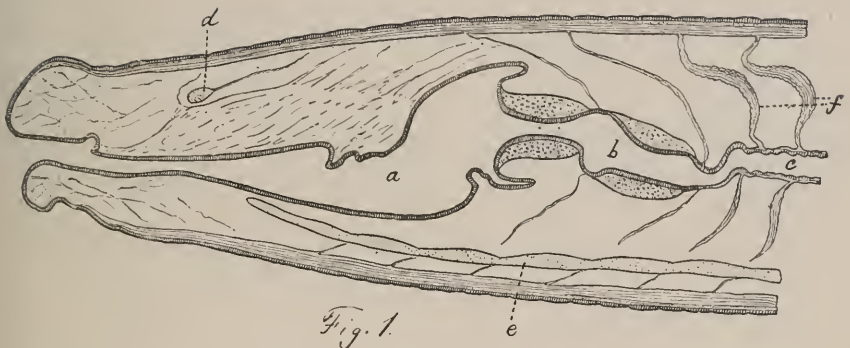

Fig. 1.

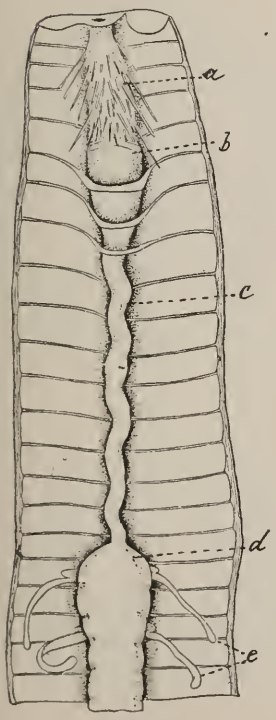

Fig. 2.

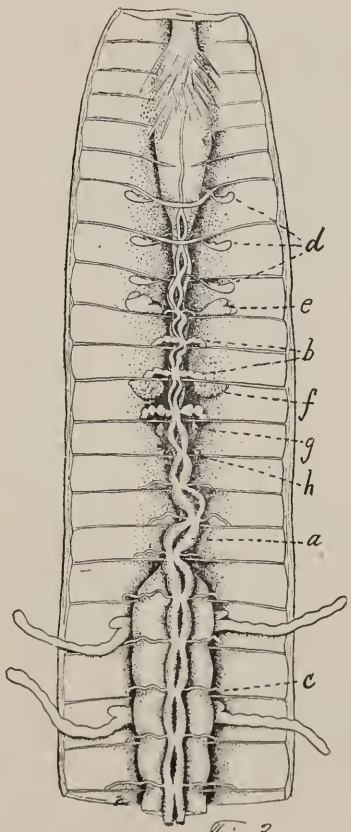

Fig. 3.

PLATE II.

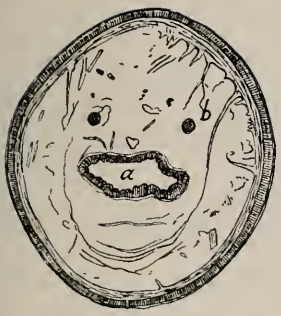

Fig. 4.

Fig. 5.

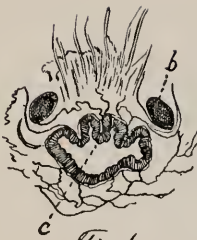

Fig. 6.

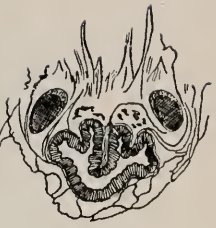

Fig. 7.

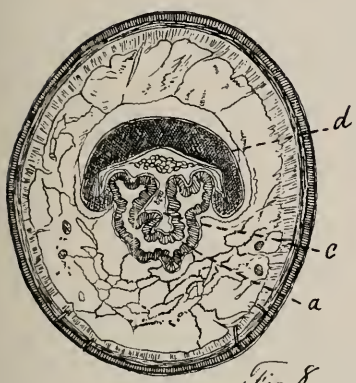

Fig. 8

Fig. 9.

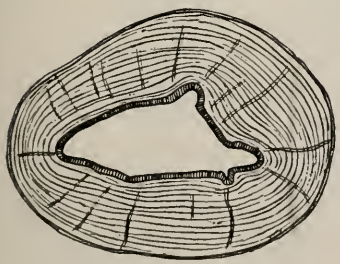

Fig. 10.

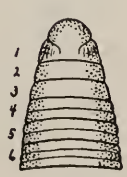

Fig. 11.

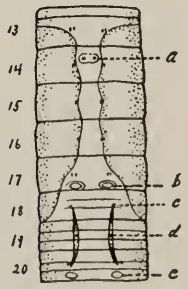

Fig. 12.

PLATE III.

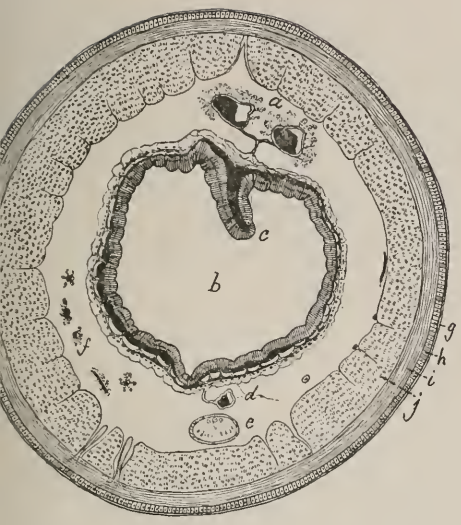

Fig. 13.

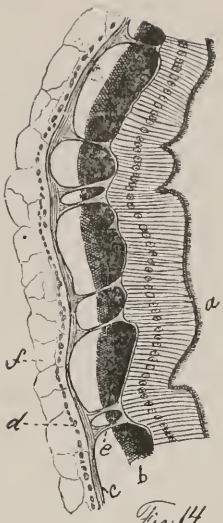

Fig. 14

Fig. 16.

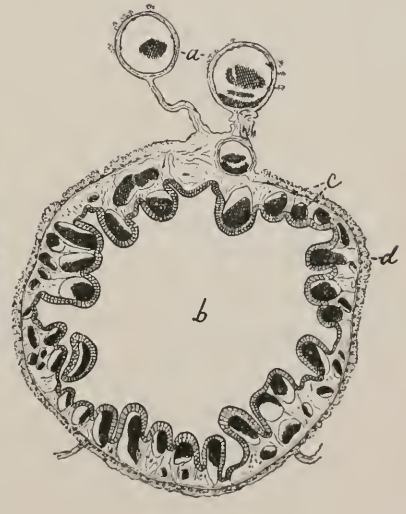

Fig. 15.

PLATE IV.

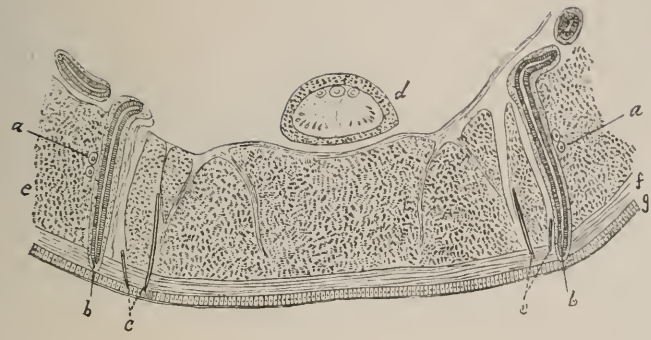

Fig. 17.

Fig. 18.

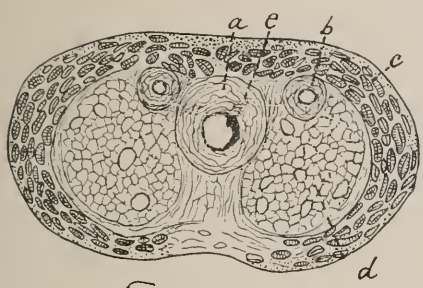

Fig. 19.

Fig. 20.

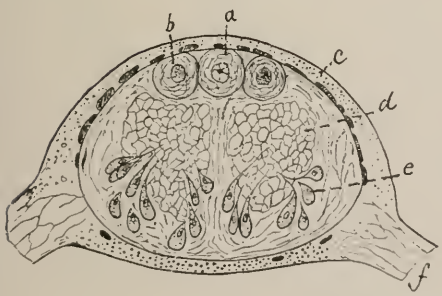

Fig. 21.

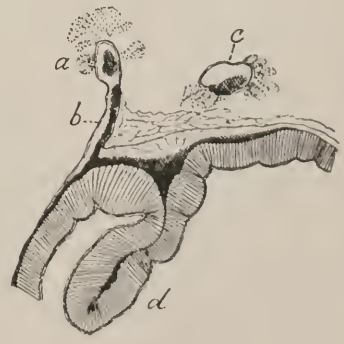

Fig. 22.

PLATE V.

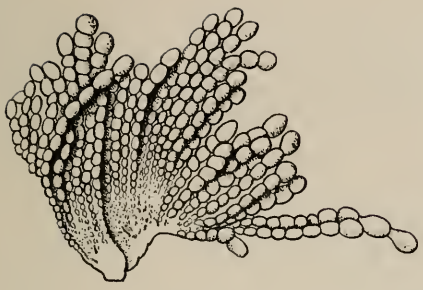

Fig. 23.

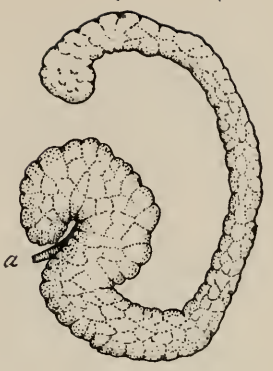

Fig. 28.

Fig. 24.

Fig. 26.

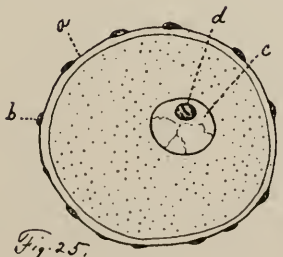

Fig. 25.

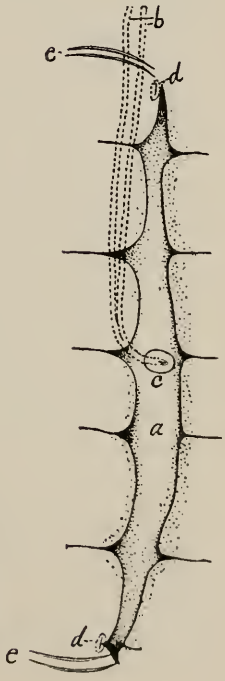

Fig. 27.

ADDENDA AND ERRATA.

To complete the list of species recognized by Stål as belonging to this family, the following are appended, not from the belief that they belong here, but because there should be no hasty change made in the classification of the Homoptera until they have been more carefully studied.*

SUBFAMILY CENTROTINÆ, Stål.

LXVI. Tolania, Stål.

276. T. opponens, Walk.

1858. *Centrotus opponens.* Walk. List Hom. B. M. Suppl. 159.

1862. *Tolania opponens.* Stål. Öf. Vet.-Akad. Förh. 491.

Hab.—Mex. (*Walker*).

LXVII. † Æthalion, Latr.

277. A. gratus, Walk.

1858. *Æthalion gratum.* Walk. List Hom. B. M. Suppl. 169.

1864. *Æthalion dilatatum.* Stål, Hem. Mex. 73, 450.

1869. *Æthalion gratus.* Stål, Bid. Memb. Kän. 299, 14.

Hab.—Mex. (*Walker*).

278. A. nervoso-punctatus, Sign.

1851. *Æthalion nervoso-punctatum.* Sign. Ann. Ent. Soc. France, Sér. 2, ix, 679, 14, pl. 14, fig. 10.

1858. *Æthalion nervoso-punctatum.* Walk. List Hom. B. M. Suppl. 168.

1869. *Æthalion nervoso-punctatus.* Stål. Bid. Memb. Kän. 299, 12.

Hab.—Mex. (*Walker*).

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*None of the species mentioned here have a prolongation of the prothorax backward, and they rightfully belong with the Jassidæ.

† There are 68 instead of 67 genera represented in this catalogue, and 282 species instead of 278, XIV., 41, 42, 43, and 44 being duplicated.

The following additional localities have been obtained since this catalogue was put in the printer's hands:

For numbers 7, 8, 140, 177, 203, 204, 205, 206, 211, and *Aconophora lanceolata*, Fairm., Guatemala (*Henshaw*); 14, 27, and 142, Me. and Mass. (*Henshaw*); 15, Ia. (*Osborn*), N. Y. (*Van Duzee*); 19, Mich. (*Cook*), Pa. (*Rathvon*), Me. (*Henshaw*); 21, N. Y. (*Lintner*); 14, 19, 22, 27, 28, 41, 53, 65, 71, 76, 85, 96, 107, 131, 216, 223, 261, Neb. (*Barber*); 28, Mich. (*Cook*), Me., Fla., Tex., Calif., and B. C. (*Henshaw*); 34, 44, 66, 91, 116, 122, 132, and 145, Mich. (*Cook*); 41, B. C. (*Henshaw*), Nev. (*Hillman*); 43, Miss. (*Weed*), Mich. (*Cook*); 46, Mass. (*Henshaw*), Mich. (*Cook*); 52, Mich. (*Cook*), Ia. (*Osborn*), Va. and Md. (*Henshaw*); 55, Mich. (*Cook*), Pa. (*Rathvon*), Ia. ? (*Osborn*), Me. (*Henshaw*); 57, Ill. (*Goding*); 65, 68, 75 (recorded as *jugata* Uhler, which is a MS. name), 131, and 261, Ia. (*Osborn*); 67, Mich. (*Cook*), Mass. and Me. (*Henshaw*); 72, Mass. (*Henshaw*); 73, 83, and 85, Ia. ? (*Osborn*); 86, Mass. and Pa. (*Henshaw*); 95, Pa. (*Rathvon*); 97, and 119, Ia. (*Osborn*), Mich. (*Cook*); 114, Mich. (*Cook*), Tex. (*Henshaw*); 121, Pa. (*Henshaw*); 136, and 192, Va. (*Henshaw*); 137, N. Mex. (*Townsend*), Col. (*Gillette*); 138, Col. (*Goding*); 188, Va., Tex., and Vict. (*Henshaw*); 194, Mass., Tex., Calif., Vict. (*Henshaw*); 198, Cent. Am. (*Henshaw*); 217, Me. (*Henshaw*); 223, Mich. (*Cook*), Anticosti, Mass., Pa., Md., Va., D. C., Oregon, and Wash. (*Henshaw*); 248, Tex. (*Henshaw*).

Page 391, line 19, for *Entomolgique* read *Entomologique*.

Page 393, for No. 5 substitute as follows: *

P. DISPAR, Fabr.

1803. *Darnis dispar.* Fabr. Syst. Rhyng. 32, 23.

1836. *Entylia dispar.* Burm. Silb. Rev. iv, 182, 2.

1869. *Parmula dispar.* Stål, Hem. Fabr. ii, 29, 1.

Hab.—Mexico (*Goding*).

Page 397, between lines 12 and 13 from bottom insert as follows: 1893. *Entilia sinuata.* Rice, Insect Life, v, 243.

Page 399, line 7, after "one" insert *female*.

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* *P. munda*, Walk., belongs to Phatnoma (*Fide* Fowler).

Page 400, between lines 9 and 10 insert as follows: 1851. *Cyphonia rectispina.* Walk. List Hom. B. M. 597, 6; line 19, for *postfaciata* read *postfasciata.*

Page 401, line 4, for *bubalus* read *diceros.*

Page 402, at bottom of page add as follows:

1891. *Ceresa bubalus.* Fletcher, Rep. Ent. and Bot. Can. 191.

1892. *Ceresa bubalus.* Osb. Trans. Ia. Hort. Soc. 119, fig. 30.

1893. *Ceresa bubalus.* Osb. Fruit and Forest Tree Ins. 24, fig. 30.

Page 403, line 21, for the interrogation point substitute a period; between lines 2 and 3 from bottom insert as follows:

1892. *Ceresa taurina.* Osb. Trans. Ia. Hort. Soc. 119.

1893. *Ceresa taurina.* Osb. Fruit and Forest Tree Ins. 24.

Page 409, between lines 4 and 5 from bottom insert as follows: *Stictocephala gillettei*, ♂. Godg. Ent. News, iii, 200.

Page 411, line 2, for *nigripes*, Stål, read *munda*, Walk.; between lines 2 and 3 insert as follows: 1858. *Parmula munda.* Walk. List Hom. B. M. Suppl. 152; line 4, for Mex. (*Stål*), read Mex. and Guatemala (*Walk.*).

Page 412, between lines 11 and 12 from bottom insert as follows:

1892. *Thelia cratægi.* Osb. Trans. Ia. Hort. Soc. 119.

1893. *Thelia cratægi.* Osb. Fruit and Forest Tree Ins. 24.

Page 413, line 12 from bottom, and page 414, line 1, for *acuminata* read *acuminatus.*

Page 414, line 11, for *Hyphinæ* read *Hyphinoë.*

Page 416, line 3 from bottom, for *Telamona* read *Membracis.*

Page 417, line 1, for *1841* read *1851.*

Page 422, between lines 8 and 9 insert as follows: 1892. *Telamona mexicana?* Godg. Ent. News. iii, 108.

Page 424, line 9, for *top* read *tips.*

Page 425, line 6, dele "fig."; line 2 from bottom, for *galata* read *galeata.*

Page 427, line 4 from bottom, for *Membracis* read *Acutalis.*

Page 429, line 15, after "lower" insert *edge.*

Pages 435 and 436. *Note.*— An examination of the types shows that numbers 122 to 126 belong to Cyrtolobus.

Page 437. After the numbers 128, 129, and 130, for *A.* read *E.* *

Page 441, line 17 from bottom, for *V.* read *Amastris* †; line 4 from bottom, insert (?) before *V.*

Page 442, between lines 8 and 9 insert as follows: 1851. *Thelia expansa.* Walk. List. Hom. B. M. 563, 26; between lines 14 and 15 from bottom, insert as follows: *Thelia marmorata.* Walk. List. Hom. B. M. 555, 4.

Page 444, line 15 from bottom, after "scar" insert as follows: Apical cell much longer than in *marmorata,* the length exceeding the breadth more than twice, while in *marmorata* the cell is but a little longer than broad; line 14 from bottom, after "fuliginous" and "yellow" substitute semicolons for commas; line 7 from bottom, after "process," add as follows: in not being suddenly depressed a short distance before apex, in not having the median carina flat from this depression, and in being much more depressed anteriorly.

Page 445, line 8. *Note.*—Through the kindness of Rev. W. W. Fowler, of Lincoln, England, I have had the opportunity to examine Stål's type of the genus Optilete, and, as surmised, it proves to be a typical *marmorata,* Say. Between lines 16 and 17 from bottom insert as follows: 1851. *Hemiptycha longicornis.* Walk. List Hom. B. M. 569, 7.

Page 449, line 10 from bottom, *Note.*— Walker's *Darnis lineola* belongs to Phacusa (*Fide* Fowler).

Page 452, No. 181, for *prunitia,* Butler, read *hastata,* Stål (*Fide* Fowler).

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* Ashmeadea being preoccupied, the name was changed to Evashmeadea.

† A more careful study of the species places it in Amastris.