XIX.—DESCRIPTIONS OF TWO FRESH-WATER OLIGOCHÆTE WORMS FROM THE PUNJAB

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(1) ÆOLOSOMA, sp.

The worm of which the following is a description is very common in and near Lahore; it inhabits standing water, and may often be found in large numbers in the foul-smelling sediment at the bottom, and also in and amongst algæ of various kinds. It lives well in small vessels in the laboratory; specimens were examined at various times during April 1907.

Examined with a lens when moving freely at the bottom of the vessel, they appear to glide smoothly forward in an extended condition, without the numerous twists, expansions, and contractions of parts of the body that are seen in the case of other small Oligochæta. On a slide and under a cover-glass they are seen to be extremely contractile, rapidly altering their shape, now short and contracted, now long and extended. They remind the observer somewhat of small Turbellarians.

The individuals vary very greatly in length, according to the degree of extension of the body, and also according to the particular phase of asexual reproduction in which they happen to be. A single individual showing no sign of approaching division may measure about 3 mm.; usually, however, specimens are longer, show one, two or more constrictions, and may reach 8 mm. There is a well-marked prostomium, followed by a narrower pharyngeal and œsophageal region; the region of the stomach is thicker again, and behind this the body is uniformly cylindrical to the posterior end. The whole body shows a large number of spherical, ovoid, or irregularly shaped green bodies scattered in the surface epithelium; their colour varies slightly; they may be a pure bright green, or green with a shade of brown, or a light yellowish-green; the latter shades were noticed more frequently, and the pure green less frequently, after the animals had lived for some time in the laboratory. I do not think that these bodies had themselves ever any tinge of blue; there appeared to be at times a bluish tinge in the other parts of the skin, due to smaller, less defined, somewhat refractile particles of a very faint blue colour, so faint as to be almost colourless.

Segmentation.—The prostomium is large, broad and somewhat shield-shaped (*v.* pl. viii, fig. 1). It is broader than the following segments, and is ciliated at its rim and on its ventral surface. No ciliated pits were seen, but ciliary action appeared sometimes to be especially well marked in two grooves leading to the angles of the mouth; possibly the grooves were not permanent. The smallest number of serial setal bundles met with in a complete animal was ten; and animals showing a larger number than this showed also, both by the arrangement of the bundles and by commencing constrictions, that they were preparing to divide (*v.* diagrams in text-fig. 1). The normal number of segments for a single individual is thus probably about eleven.

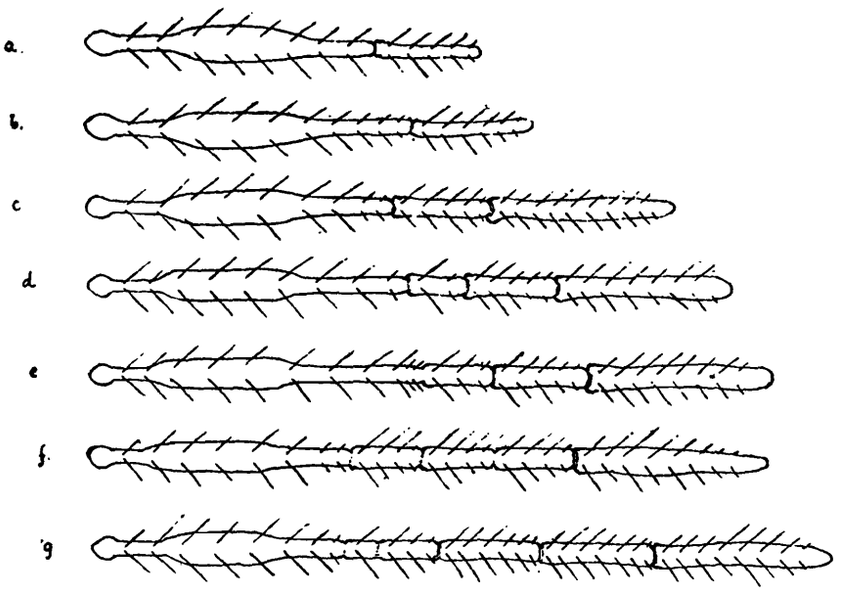

FIG. 1.—Diagrams illustrating various phases of asexual reproduction in *Æolosoma* sp.

Asexual multiplication.—Diagrams illustrating various phases are shown in text-fig. 1. It will be seen that the anterior, or original, animal of the chain bears eight, nine, ten or eleven serial setal bundles; but of these the last, or the last two or three, are evidently (as is indicated in the diagrams) of new formation. The zone of budding, therefore, seems to arise after the seventh or perhaps sometimes the eighth setal bundle, *i.e.*, after the eighth or ninth segment; and the intercalation of two or of three segments in this place and subsequent fission would give us the "normal" individual of eleven segments referred to above. In the hinder part of the chain the division into individuals seems to be much more irregular; thus in text-fig. 1 *f* we appear to have had the establishment of three zones of budding behind each of three originally successive segments.

Setæ.—Both dorsal and ventral setæ are of the same type,—long, smooth, straight, hair-like; in both dorsal and ventral bundles, however, shorter setæ may be present, sometimes alternating with the longer ones in their position in the bundle; but though

varying in length all are of the same type. The *ventral* bundles contain usually from four to six setæ; the *dorsal* bundles contain from two to six and are, on the average, somewhat longer than the ventral. The general length of the setæ may be said to be about equal to the diameter of the animal. Both groups of setæ begin in the second segment.

Body-cavity.—There are no lymph-corpuscles in the body-cavity. There is one very definite septum, at the sides of the pharynx, representing the division between first and second segments. Besides this there are a large number of connecting strands between the alimentary tract and the body-wall: they are fine and thin in the region of the pharynx, thicker posteriorly between the intestine and body-wall, where they have a granular protoplasmic appearance. At the site of a future division they are thicker and more numerous, the condition almost amounting to a fusion between intestine and body-wall. Numerous strands are inserted into the dorsal blood-vessel.

Alimentary tract.—The mouth is bordered ventrally by a prominent lip, mobile and ciliated. There is no buccal cavity separate from the pharynx; the œsophagus occupies the second and third segments and is of approximately uniform diameter throughout; bunches of oval or spherical granular cells may be seen attached to it in a grape-like fashion, especially posteriorly (*v.* pl. viii, fig. 3). The stomach occupies segments 4-7; it is not very sharply delimited from the intestine; it may contain in its wall a number of spherical colourless globules, or perhaps vacuoles, about the same size as the green bodies in the skin. The intestine, which follows, may also contain a number of particles in its walls; but these are more refractile, less regular in shape, somewhat smaller, of a faint bluish tinge, and are apparently of the same nature as the similar bodies described in the skin; they also occur in the wall of the dorsal blood-vessel. Antiperistalsis is frequently observed throughout the length of the alimentary canal as far forwards as, and sometimes including, the stomach; and a reversed ciliary action (postero-anterior) is constantly going on in the intestine. Diatoms and mineral particles are found in the stomach and intestine.

Vascular system.—The blood is colourless and contains no corpuscles. The dorsal vessel is contractile; it bifurcates in the prostomium in front of the mouth, and the branches unite to form the ventral vessel beneath the pharynx. There are no transverse commissures.

Nephridia.—The nephridia are coiled tubes, with small ciliated funnels lying unattached in the body-cavity. The first occurs behind the first setal bundle; seven may sometimes be distinctly counted, while at other times there are apparently only six. None appeared to be modified in any way.

Nervous system.—The cerebral ganglion appears under two shapes; sometimes as a simple, transversely placed oval mass, sometimes having in addition two lateral, posteriorly directed,

rounded cornua. It is much easier to see in some cases than in others, but is never very prominent. While the two forms shown in fig. 4 may certainly both be recognised in different animals, the difference may possibly be explicable, partly at any rate, by a difference in the degree of protrusion or retraction of the prostomium; the effect of protrusion might be to double back the ends of a normally oval-shaped, transversely-placed ganglion. I have, however, no observations to show whether this is so, as it is impossible to follow the shape of the ganglion during any movement of the animal. There are no pharyngeal commissures and no ventral cord. Fine hairs, perhaps sensory, are distributed over the whole body. On the under surface of the prostomium are certain cells which stain a deep blue on the addition of a little methylene blue to the water in which the animal is being examined; these may perhaps be special sense-cells.

No *genital organs* or clitellum were seen.

The above described species of Æolosoma appears to have most affinity with *Æ. headleyi*, Beddard, of which I transcribe the specific characters as given in Michaelsen's *Oligochæta.* "*Kopflappen breiter als die folgenden Segm. Oeldrüsen leuchtend grün, manchmal ins Bläuliche spielend. Borsten sämtlich lang, haarförmig, S-förmig geschweift. Gehirn hinten grade abgestutzt* (?). 8-9 *Nephridien-paare, erstes hinter dem* 1 *Borstenbündelpaar. Mässig gross* (*L. ca.* 2·5 *mm.* ?)."

The question of colour and of the site of the element of blue in the species here described has been entered into above, and also the question of the shape of the cerebral ganglion, about which in *Æ. headleyi* there would appear, from Michaelsen's note of interrogation, to be some doubt; I do not, however, think that in any case its shape could, in the species now described, be said to be "cut off straight behind." A greater number of nephridia is given for *Æ. headleyi* than those I have been able to count. The length is perhaps not a very important point.

There remains only the question of the setæ. I cannot find that in this species there is any S-shaped curve; they may, of course, be temporarily curved through the resistance of the water or pressure of the cover-glass; but examined at rest, without a cover-slip, such a curve, if present at all, is of the very slightest, and is not S-shaped.

The general resemblance, however, of this form to *Æ. headleyi* would appear to be considerable, and it may be possible to unite the two under that name.

The above species will doubtless receive formal description and a specific name from Dr. Michaelsen in his Monograph on the Indian Oligochæta, soon to appear; as, however, it is difficult to be certain of details of internal anatomy in preserved specimens, it seemed worth while to give a description based on examination of the living animal; so that, although appearing before Dr. Michaelsen's work, the above notes are really supplementary and logically posterior to it.

(2) CHÆTOGASTER PELLUCIDUS, n. sp.

The following interesting form was obtained in the tank in the pleasure-gardens at Shalimar, and was also found in fair numbers in the duck-pond in the Lahore Zoological Gardens. Specimens were under observation in the laboratory at various times during April 1907.

External characters.—The worm is much larger and thicker than *C. punjabensis*, recently described from Shalimar. The ordinary length is about 5 mm., but some of the longer chains, especially when extended, may reach 10 mm. Its general shape will be immediately understood by a reference to the figures in plates ix and x; fig. 1, however, was drawn from a somewhat contracted specimen, and the usual shape is more accurately expressed by some of the other drawings. The animal is very transparent.

It seems unnecessary to describe a prostomium, the mouth being large, obliquely placed ventro-anteriorly, and reaching to the anterior extremity of the animal. The pharyngeal region is beset externally with a large number of minute irregularities, probably small chitinoid, or at least cuticular, elevations (*v.* fig. 1), mostly elongated in an antero-posterior direction; their shape and disposition are represented in text-fig. 2. The anus is terminal. The animal is very contractile, and may, in this condition, appear to be little more than half its normal length, and double its normal thickness. It moves largely by means of these contractions and extensions of the body assisted by its setæ; in backward progression the hinder end of the body may be first over-extended, then sharply flexed; the setæ, with their points directed forwards, are thus brought to impinge forcibly on any subjacent object, which serves as a point of resistance as the animal thus jerks itself backwards. In anterior progression the points of the setæ are directed backwards.

Segmentation.—The rudimentary nature of the prostomium has been mentioned; neither it nor any of the succeeding segments are marked off by any external annulation, and other means of delimiting the segments also fail us in the anterior part of the body. As elsewhere, the first group of setæ may be supposed to mark the second segment; but posterior to this there is a region of the body which is entirely achætous, which possesses no nephridia, where the ventral nerve cord is not marked by distinct ganglia, and where the septa also are irregular or wanting. There can, however, be little doubt that the second group of setæ belongs to the sixth segment, since this is the rule in the genus *Chætogaster*, to which in other respects the present form shows a close correspondence. In *C. punjabensis*, for example, the segments can be counted by means of the septa; and there can be no doubt of the close relation between that species and the present form. The body is continued posteriorly to a variable length, the segments being marked throughout this extent by definite septa, by the setal bundles and by nerve ganglia. The shortest animal I have met with (text-fig. 2) showed in all eleven segments, and this may be taken as the normal length of a single individual.

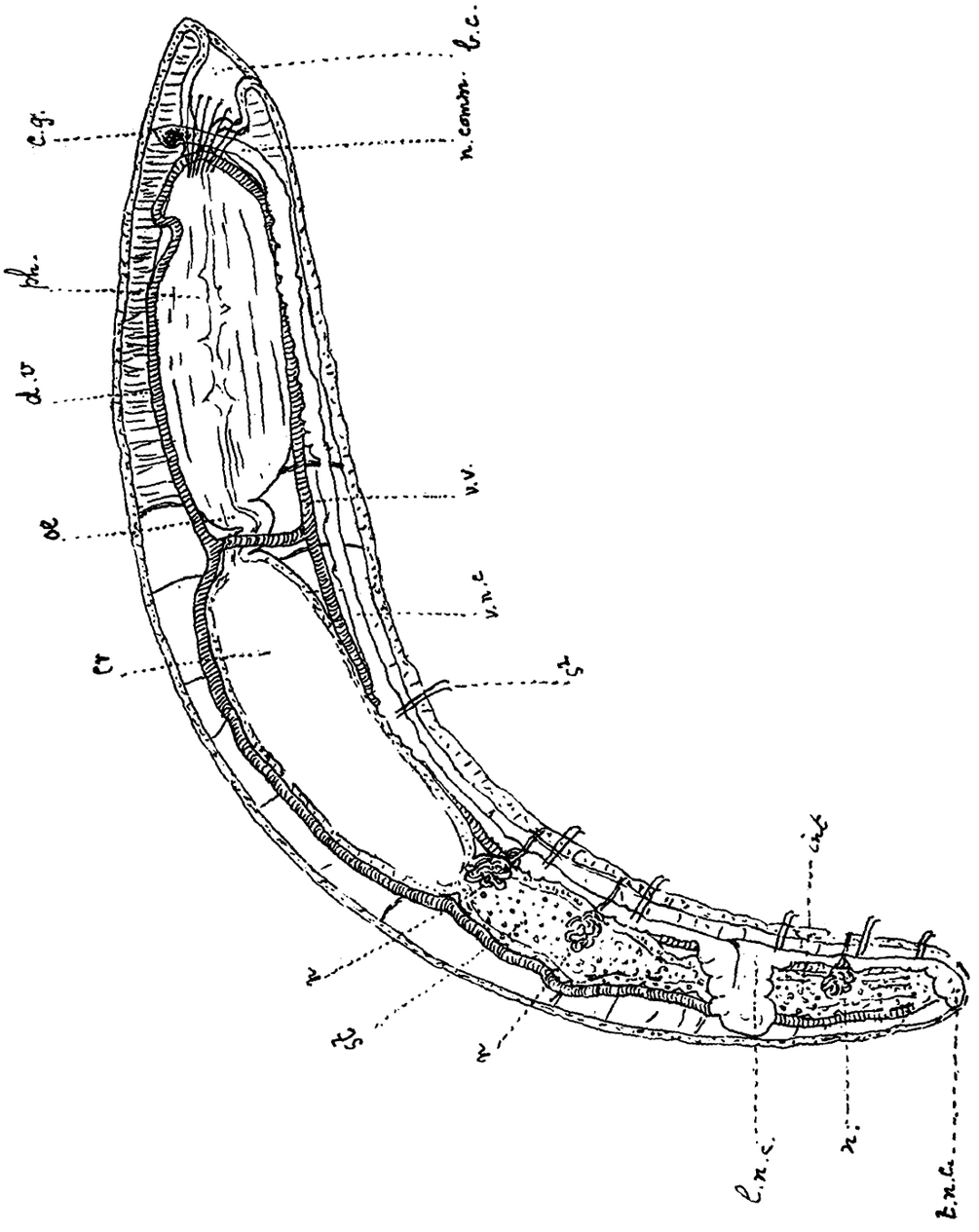

FIG. 2. – An animal of eleven segments; the lateral expansions of the nerve-cord are well seen. The blood-vessels are indicated by cross-shading. The nephridia here and in subsequent figures are diagrammatic.

Asexual reproduction.—The "normal single individual" is, however, very rarely met with; since in the large majority of cases indications of approaching fission are evident. Indeed, speaking strictly, I believe that such indications are always to be met with, and that even in the specimen represented in text-fig. 2, the arrangement of the nephridia and the lateral extension of the nerve-cord (here unusually evident) indicate preparations for renewed division.

Figure 3 shows a specimen which is slightly longer than the above, has an additional nephridium, and is producing new segments posteriorly, as indicated by the terminal minute new setæ. This—and the same applies to several of the figures referred to in the following few paragraphs—was drawn originally to illustrate other points; the nerve-cord is here not represented, but an irregularity of the septa about the ninth and tenth segments probably indicates the production of new segments at this place.

Figure 4 represents a considerably longer animal. A definite constriction divides it into two halves, of which the anterior is in exactly the condition of text-fig. 2; the posterior contains also three nephridia, with an interval between the second and third, where a lateral extension of the nerve-cord is beginning to grow dorsalwards. This posterior portion evidently only requires the elongation of its fore-part and the addition of the first setal bundles to bring it also into the stage of the animal represented in text-fig. 2.

Figure 5 shows this elongation and addition of the first setal bundles (directed from the first forwards, not perpendicularly outwards) as having taken place. But in this and the subsequent examples the two chief components of the compound animal have, before separation, developed further than the already separated individual of text-fig. 2, which seems to have become free at an unusually early stage. There seems here to be a slight irregularity in the development of the nephridia.

Figure 6 shows, as measured by the number of segments and the development of the nephridia, a more advanced stage than the last, though the actual division into two is apparently more remote. It shows a typical distribution of the nephridia; and a number of extremely minute, newly developing setal bundles, distinguishable only with the high power, afford a good demonstration of the various positions where new segments are being intercalated.

Figure 7 illustrates again the slight irregularities which may occur in the time of appearance of the nephridia. This specimen contains one nephridium less than the last, though the most anterior setal bundle of the posterior component is better developed, and the minute setæ at the zones of budding are—or were in the original specimen—rather more in evidence. In this, as well as figs. 5 and 6, it will be seen that attention has been paid to the irregularities of the skin surface at the sites of future division. Figure 1 shows a very similar stage.

The longest animal of which I have any note, was also the only one in which reproductive organs were seen. Sexual and asexual modes of reproduction do not, therefore, exclude each other, Here the two chief components each consisted of three portions.

so that the whole chain was composed of six individuals or their rudiments. As regards the posterior of the two chief components, its anterior section was sufficiently distinct, while a further subdivision in front of the sixth setal group, reckoned from behind, was evidenced by the constriction and absence of nephridia at this part. The corresponding subdivision in the anterior animal was less evident owing to the non-development, up to that time, of nephridia behind the level of the slight constriction.

We can now, I think, summarize the history of asexual reproduction in this species as follows: The normal single individual consists of about eleven segments, but, in the spring of the year at any rate, it is seldom found, and does not usually separate till it has attained a greater length than this. It contains, typically, two nephridia in the seventh and eighth segments; it also shows already a zone of budding behind the eighth segment; a nephridium, if present in the tenth segment, will ultimately become the first of a posterior animal. About eight segments are intercalated at the zone of budding, the three anterior of which belong to the anterior half, and the five posterior become the anterior five segments of the second animal; the setæ of the ninth original segment become the second setal bundle, *i.e.*, the setæ of the sixth segment, of the second animal. The posterior end of the whole animal produces three new segments, whereby we now have twenty-two in all, eleven for each half. The animal, however, seldom divides at this stage, the components remaining attached until at least a part of the above cycle has been repeated in each of them.

Setæ.—There are no dorsal setæ. The ventral setæ are slender, somewhat small compared with the size of the animal, slightly curved in an $\int$ shape, with two unequal prongs and a small nodulus (*v.* text-fig. 3 A). Those of the second segment are directed

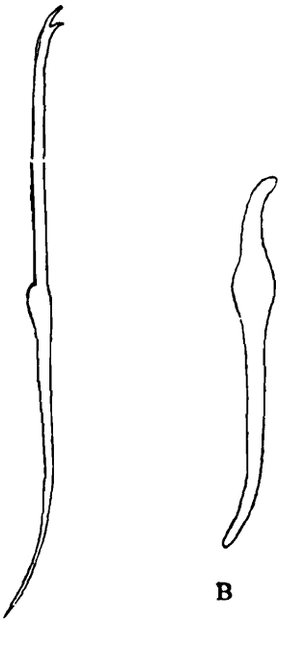

FIG. 3.—A, ventral seta of *C. pellucidus*; B, genital seta.

anteriorly, and when brought into use are spread out in a fan-shaped manner; they do not, at rest, reach the mouth, and I have not seen them used for prehension of food. The next bundle of setæ belongs (*v.* ant.) to the sixth segment, and is situated about the junction of the middle and posterior thirds of the crop. The two following bundles are placed in the region of the stomach; other bundles follow segmentally to the posterior end of the body.

The number of setæ in each bundle is very commonly five; or, in the second segment, six or seven; two, three and four are also met with.

In the only specimen met with which showed sexual organs, the setæ of the sixth segment were modified (*v.* text-fig. 3 B). They were shorter, stouter, with well-marked nodulus, not forked, and did not project. In another specimen which, however, had no sexual organs, these setæ were shorter than those of the next segment, and did not project as much; they had the usual two prongs.

The setal sacs are not conspicuous, the internal ends of the setæ appearing to be merely connected with a number of fine radiating contractile strands. The setæ may be rotated; the hooked free end pointing sometimes forwards and sometimes backwards, according to the direction of progression, except probably in the case of the first setal bundle.

Body-cavity.—The body-cavity is traversed by septa, of which the first is well-marked, thick and situated behind the pharynx; the second is thinner and is placed at the beginning of the crop; these two may be taken as delimiting the second and third segments posteriorly. The next definite septum is near the posterior end of the crop, and there is also a septum at the middle of the stomach; these show the extent posteriorly of the sixth and seventh segments: septa occur intersegmentally in the posterior part of the animal.

Besides the septa, there are a number of irregularly placed fine strands passing between alimentary canal and body-wall, especially numerous and perhaps contractile in the region of the pharynx.

On one occasion a number of corpuscles were observed in the body-cavity; these contained a number of colourless, refractile, oil-like globules, of different sizes, in their substance. Usually, however, the body-cavity is free from corpuscles.

Alimentary canal.—The mouth is large, circular, placed ventro-anteriorly, and reaching as far as the anterior tip of the animal. The buccal cavity (*v.* text-fig. 4 C) succeeds, with the nerve commissure round its sides; the pharynx is conspicuous, occupying the second segment, attached by strands to the body-wall, and having normally only a narrow lumen. The œsophagus (text-fig. 2, and pl. ix, fig. 1) is a narrow tube leading to the crop; it occupies almost the whole of the third segment. The crop is the dilated portion of the canal in the fourth, fifth, sixth and part of the seventh segments; it is usually empty, and its walls are clearer than is the case in the stomach and intestine. A constriction in the seventh segment separates the crop from the stomach, the latter being also distinguished from the crop by the number of yellowish, refractile,

oil-like globules in its wall: it frequently has a somewhat rhomboidal shape, owing to its being pulled out laterally by the attachment of the septum. The intestine follows, also dilated at the insertions of the septa; its walls are of the same character as those of the stomach. Ciliary motion may sometimes be detected in the intestine, but it is not of a conspicuous character, nor definitely in a postero-anterior direction, as is commonly the case in small aquatic Oligochæta.

These animals are carnivorous; on two occasions I found two specimens on a dead fly in the water; the stomach and intestine of others showed Paramœcia and other Ciliata, small Crustacea, Rotifers and Anguillulæ in their interior.

Circulatory system.—The dorsal vessel is contractile, the contractions progressing from behind forwards; it is attached to the dorsal wall of the intestine, stomach, crop and œsophagus, except at the angle between œsophagus and pharynx; it is again attached to the wall of the pharynx in its posterior part, and becomes free anteriorly before it divides. It is continued as two lateral vessels at the sides of the buccal cavity, immediately posterior to the nerve-commissures (*v.* text-fig. 4 C), which unite

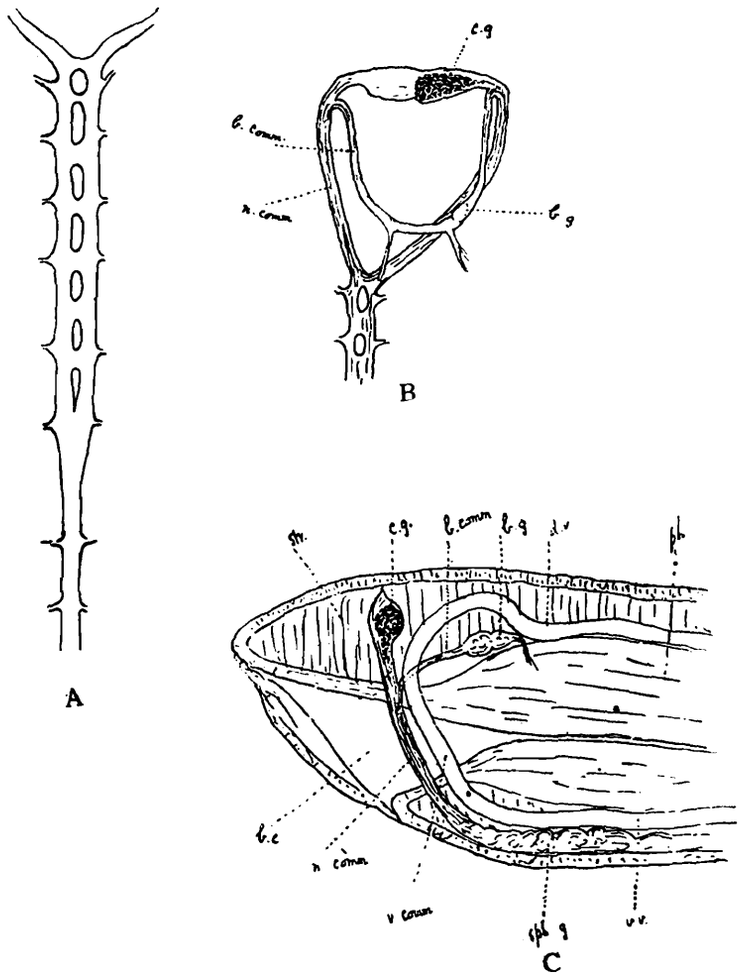

FIG. 4.—A, anterior part of ventral nerve cord of *C. pellucidus*, in the extended condition; B, cerebral and buccal ganglia and their commissures; C, anterior end of animal, from the side. (Reference letters as in Plates ix and x.)

ventrally in the ventral vessel. This is not contractile and is not attached to the wall of the alimentary canal. A pair of transverse connecting vessels (*v.* text-fig. 2) which are contractile are situated in the œsophageal segment in front of septum $\frac{3}{4}$. There is a capillary plexus in the wall of the crop similar to that described in *C. punjabensis* (*v.* pl. ix, fig. 10). The blood is colourless and contains no corpuscles.

Nephridia.—The nephridia are long, finely coiled tubes, not attached to the septa, and without funnels; no ciliary motion is visible within them. Their position has been described above, and may be seen in the various figures.

Nervous system.—The cerebral ganglion is situated dorsal to the buccal cavity; it is indistinctly bilobed, elongated transversely, and may appear somewhat nodular in outline. The commissures are continued from its antero-lateral angles. The ganglion frequently contains a quantity of granular opaque matter; this may be aggregated into an ovoid mass (text-fig. 5 A) in the

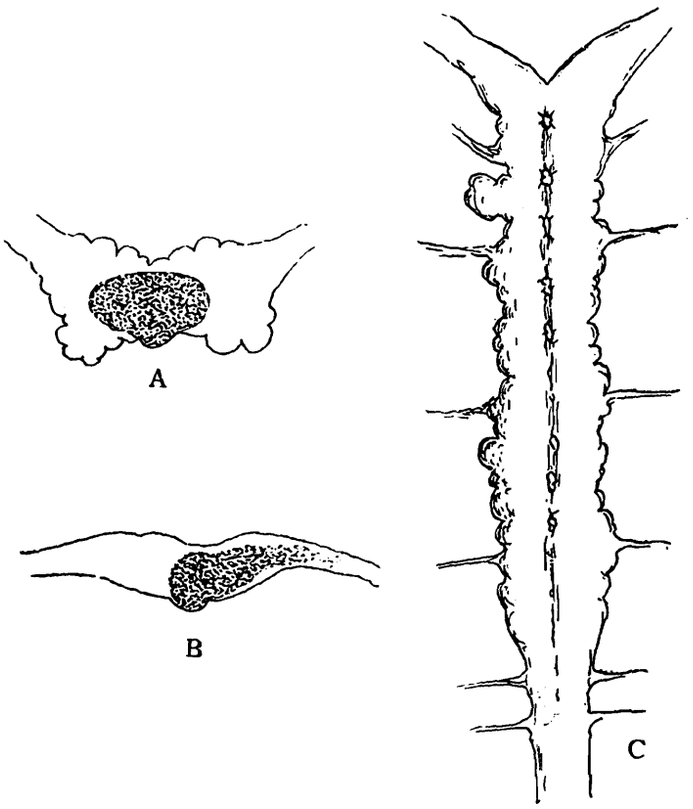

FIG 5.—A, cerebral ganglion of *C. pellucidus*, with symmetrical ovoid granular mass; B, the same, granular matter mainly unilateral; C. anterior part of ventral nerve-cord, in the usual somewhat contracted condition of the animal.

deeper and more posterior part of the ganglion; or it may extend as scattered granules some distance along the commissures; or it may be confined to the right (text-fig. 5 B) or left half of the ganglion; or it may be absent altogether. But even when most closely aggregated, the mass never has the bright shining appearance of the refractile particle in the cerebral ganglion of *C. punjabensis*, but is always dark and opaque.

The commissures lie at the sides of the buccal cavity and unite below; about one-third of their length from the cerebral ganglion they each give off a branch which proceeds in a posterior and dorsal direction, and curving inwards unites with its fellow in a loop dorsal to the pharynx; this loop shows two ganglionic swellings, one on each side, which are very evident in text-fig. 6,

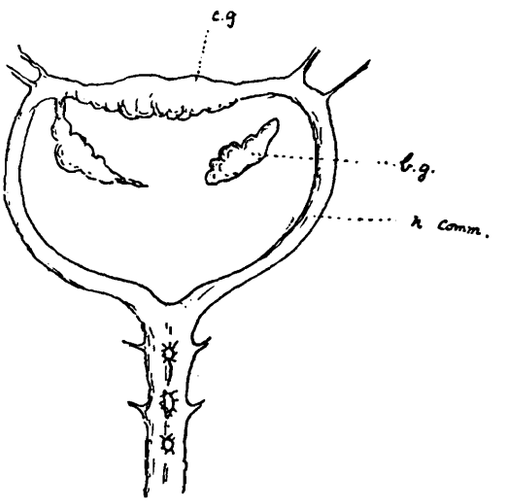

FIG 6.—Anterior part of nervous system of *C. pellucidus*: buccal ganglia obvious, buccal commissures indistinct. (Reference letters as in Plates ix and x.)

though the connecting strands were here scarcely discernible. The fibres appear to enter the loop from the ventral portion of the buccal commissure, not from the direction of the cerebral ganglion (*v.* text-fig. 4 B and C).

The ventral nerve-cord shows the longitudinal division into two in its anterior portion, which is characteristic of the genus. This is best seen when the animal is well extended; the separation between the halves then takes the form of elongated oval spaces with bridges passing from side to side between them. In the much more usual (under examination) somewhat contracted condition, the longitudinal division of the cord is much less marked, and appears as a series of small circular buttonholes with puckered margins (*cf.* text-figs. 4 A and 5 C); in this condition the outline of the cord is irregularly nodulated. This longitudinal division extends almost as far as the posterior end of the pharynx.

The ganglia are placed in each segment after the fifth at the level of the setal bundles. In the anterior part of the body they are not clearly distinguishable, though on a lateral view a slight thickening of the cord appears to exist anteriorly where it is formed by the union of the commissures, and again just behind the posterior limit of the pharynx. The first ganglion, however, that is clearly recognisable is that of the sixth segment; all are seen better in a lateral view than in one from the ventral surface.

The lateral expansions of the nerve-cord at the site of a future division of the animal have been already referred to, and are illus-

trated in text-fig. 2; the terminal expansion in this particular case probably denotes that the animal has recently divided. The expansions are quite similar to those I have already described in *C. punjabensis*; they are more marked on the posterior side of the actual line of constriction, where they appear to develop into the nerve-commissures of the posterior animal (*cf.* some examples in figs. 5 and 6).

Sense organs.—A few fine hairs are seen at the anterior end of the body. The granular matter in the cerebral ganglion doubtless corresponds to the refractile particle in the same situation in *C. punjabensis.*

Reproductive organs.—I found these organs only in one specimen (which was also dividing asexually), although within a few days of this I looked through a fair number of examples with a view to discovering others.

The male organs (*cf.* fig. 9) are situated opposite the middle region of the crop; a small spherical mass, in which no structure could be discerned, and seen only on one side, perhaps represents the testis; to its outer side lies a tube, straight or doubly bent, ending internally in a dilated portion, and externally on the surface at the level of the setæ of the sixth segment. A swollen part of this tube near its external aperture is occupied by an ovoid somewhat granular mass, and the external aperture itself is funnel-shaped. I could not distinctly see an internal opening at the other end of the tube, nor was ciliary motion anywhere visible. The genital setæ have already been described; there is a development of hairs around the aperture; and the skin is thickened here, so that seen laterally (fig. 10) there is a slight protuberance.

Scattered throughout the body, in the posterior as well as in the anterior of the two as yet undivided animals, were numerous sperm-morulæ; various stages in the development of these are represented in fig. 8, beginning with a small globular hyaline mass, in which the individual cells are but faintly visible with the high power of the microscope, and ending with a wisp of enveloped spermatozoa. The male products would therefore seem to ripen while floating free in the body-cavity.

The ovaries, of which one is shown in fig. 9, develop on the anterior face of septum $\frac{6}{7}$; one ovum, in the figure referred to, is seen to be much larger than the rest; it had a clear refractile germinal vesicle which was enclosed by a zone of protoplasm somewhat clearer than that composing the mass of the egg. The receptacula seminis (as I take them to be) are two sacs, attached near their fundus to the septum at the anterior end of the crop (septum $\frac{3}{4}$), and opening exteriorly as shown in fig. 9: they were of a hyaline appearance, and no distinct structure could be observed. No oviducts were seen. No clitellum was distinguishable.

The specimen whose reproductive organs are here described was examined on April 24th; the water containing it had then been kept in a vessel in the laboratory for a few weeks.

GENERAL REMARKS.

The animal described above agrees in most points with the definition of the genus *Chætogaster* as given by Michaelsen. It differs, however, in not possessing a greatly elongated third segment, which is a characteristic of the genus as described by him; for though, as has been said, there is some difficulty in delimiting the anterior segments, still the third appears to be defined by septa on each side, and, as in *C. punjabensis*, to be practically commensurate with the œsophagus; and apart from this, whatever the exact limits of the first six segments may be, there is hardly room for any one of them to be "greatly elongated" without cramping some of the others almost out of existence. The receptacula seminis of this genus are also said to be in the fifth segment, while I have described them above as attached to the posterior face of septum $\frac{3}{4}$; I would not, however, lay too much stress on the condition of the single, apparently not fully developed, specimen, in which these organs were found.

On the other hand, the resemblances between this form and the various species of the genus *Chætogaster* are many and evident; such, especially, are the absence of the dorsal and the arrangement of the ventral setæ, the single pair of lateral transverse blood-vessels, and the separation longitudinally of the anterior part of the ventral nerve-cord into two. It will be better, therefore, for the present to place this form in the genus *Chætogaster*, as was done with *C. punjabensis*, and as Annandale has done with the allied species recently described by him; and I propose the specific name *pellucidus* for it.

Besides the presence of the cuticular prominences on the head, the distribution of the nephridia, the details of the asexual mode of reproduction, and the co-existence of asexual with sexual reproduction, a few further points of interest present themselves for remark.

With regard to the granular matter contained in the cerebral ganglion, it is interesting to recall the crescentic refractile particle in *C. punjabensis*, the sense-organ (? otocyst) in the cerebral ganglion of *C. bengalensis* (Annandale, *Journ. Asiat. Soc. Beng.*, New Ser., vol. i, No. 4, 1905, p. 117), and the definite otocyst (a relatively large, globular, transparent cyst) of *C. spongillæ* (*ib. id.*, vol. ii, No. 5, 1906, p. 188). With this may perhaps be brought into connection the condition in *C. diastrophus* (Gruith.), a European species, in the definition of which Michaelsen says, "gehirn mit medianer Chitin (?)-Platte am Hinterrande." It seems possible that we have here a series of degenerative changes, from the fully-developed organ of *C. spongillæ*, through the doubtful otocyst of *C. bengalensis*, to the apparently solid aggregate in the brain of *C. punjabensis* and the chitin-like plate at the posterior part of the brain of *C. diastrophus* (*cf.* the position in *C. punjabensis*); finally we have the dispersal in granular form of this solid matter, as in most specimens of *C. pellucidus*, or its entire absence, as in other

specimens; the variability in amount and distribution of this granular matter being perhaps correlated with the fact of its being here a "rudimentary organ."

What may be called the "buccal nerve commissure" does not appear to have been described in other species of *Chætogaster*; but here again *C. diastrophus* shows a related condition, the œsophagus being surrounded at its middle by a ganglionic ring. In *C. crystallinus* (Vejd.) a similar ring surrounds the anterior end of the œsophagus; and the condition in *C. pellucidus* may be derived from this by supposing a still further forward shifting of this ring, which now takes origin from the commissures at the sides of the buccal cavity; as might be expected on the supposition of the homology of these structures, the fibres of the buccal commissure of *C. pellucidus* are derived from the ventral side, not from the cerebral ganglion.

The genital hairs and genital setæ seem worthy of note. The latter appear to be modified in a direction contrary to what is usual; they abort to some extent, and cease to project. Since in this form the normal setæ (and the same is the case in *C. punjabensis*) project ventrally in a vertical direction, with little or no lateral inclination, they could, if retained, only be a hindrance to copulation, and their abortion probably allows a closer apposition, necessary in the case of aquatic forms.

As to the segments in which the reproductive organs are contained, the ovary is evidently in the sixth segment; as, being at the level of the setæ of this segment, is also the opening of the vas deferens. The anterior portion of the vas deferens and the testis may, following the rule for the genus, be supposed to lie in the fifth segment, though there is here no means of fixing segmental limits. As previously said, the receptacula appear to be in the fourth segment; this is unusual in the Naididæ, and it may possibly be the case that the septa in front and behind the œsophagus are septum $\frac{3}{4}$ and $\frac{4}{5}$ respectively, not $\frac{2}{3}$ and $\frac{3}{4}$ as I have assumed; in this case the œsophagus would occupy the fourth, not the third segment, and the pharynx both second and third, there being then no septum between the second and third segments. My numbering of the anterior segments of *C. punjabensis* would also in this case require revision.

The absence of a clitellum, and the development of the spermatozoa while floating in the body-cavity are noteworthy.

On the Indian Species of the Genus Chætogaster.

Michaelsen (Oligochæta) in 1900 enumerates five species of Chætogaster, all from Europe. Annandale, in describing *C. bengalensis*, mentions that the genus has also been found in America, referring, perhaps, to *C. gulosus*, Leidy, 1852, which Michaelsen calls doubtful, and of which he gives no description. Within the last two years five species have been recorded from India, so that the extent of the genus has been doubled. The new species

are *C. bengalensis* and *spongillæ* from Calcutta, described by Annandale (*loc. cit.*); another species not yet fully described and referred to by Annandale, its discoverer, in his second paper as *C. sp.*; and *C. punjabensis* and *pellucidus* from Lahore by me.

The literature of the European (and American) species is not accessible to me; but they appear to form a well-marked, homogeneous group, which, while agreeing with the Indian species in its broad outlines are separated from these latter by the elongation of the third segment and the absence of sense-organs or their rudiments. As to the first of these points, whatever be the exact delimitation of the segments in the anterior part of the bodies of the Indian specimens, it can be seen by referring to the published figures (as has been already mentioned for *C. pellucidus*) that, taking the first setal bundle to belong to the second segment, and the second setal bundle to the sixth, there really is no room in any of them for a greatly elongated third segment. As to the second point, the chitinous (?) plate in the brain of *C. diastrophus* may represent a link of connection between the two groups. Another connecting link between the groups may be seen in the buccal nerve-commissure of *C. pellucidus* which, as stated above, may be compared with the circum-œsophageal ganglionic ring of two of the European species.

But whatever may be the case regarding these two geographical groups and their relationship, the Indian species appear to me to be closely related and to form a well-defined assemblage. Besides the characters already mentioned, which differentiate them from the European species, the conformation of the alimentary canal and, as I hope to show, the normal number of segments of the animal and the mode of asexual reproduction, agree in the various members. The small cuticular projections on the head of *C. pellucidus* are also to be compared with the longitudinal rows of minute irregular tubercles on the head of *C. spongillæ* and the small projections of the epidermis on the ventral surface of the anterior sucker of *C. bengalensis*; and the peculiar shape of the nodulus (the projection being one-sided and more abrupt distally) on the setæ of *C. bengalensis* and *pellucidus*—though it may be found not to be confined to these two species—seems worthy of note.

The mere reading of the descriptions of the alimentary tract would lead one to suppose that there was a marked difference between the Punjab and Bengal forms. For example, in *C. bengalensis* Annandale speaks of a narrow slightly coiled passage succeeding the pharynx, and leading into the œsophagus; the œsophagus being a large sac (*v.* fig. in text) divided by a permanent constriction into two: to the œsophagus (which is thus the longest part of the alimentary tract) succeeds the intestine. The Punjab species, on the other hand, are described as having a small œsophagus, large dilated crop, stomach also considerably dilated, and lastly the intestine. It is, however, easy to see by referring to the figures that Annandale's "slightly coiled passage" is my œsophagus; the first dilatation of the œsophagus corresponds to the crop, and

the second to the stomach. I had not seen Dr. Annandale's paper when I wrote my description of *C. punjabensis*; and in the above account of *C. pellucidus* I have followed my former nomenclature, since it still seems to me more convenient to have separate names for permanent and separate structures; and so long as such names are not taken to imply homologies I think they are unobjectionable. Dr. Annandale, having access to the literature of the subject, may have used his names in accordance with the practice of European writers on the genus; though it appears that in those species the œsophagus is small, and never longer than the pharynx. In any case, if the terms "crop" and "stomach" are rejected, I would suggest that the division between "œsophagus" and "intestine" be taken at the line between my "crop" and "stomach," —not behind the "stomach"; the difference in character of the walls changes at this point, at least in the two species with which I am acquainted. Detailed descriptions of the alimentary tract of *C. spongillæ* and *C. sp.* are not given; but the same two dilatations, in the same relative positions, are seen in the figures of both; and in all five species the relation of the crop (or first dilatation of the œsophagus) to the setæ of the sixth segment (which occur about one-third the length of the crop from its posterior end), and of the stomach (or second dilatation of the œsophagus) to those of the seventh and eighth segments, is the same.

The above is merely a question of nomenclature; what follows has to do not merely with nomenclature, but also with a difference of interpretation, especially with regard to the appearances which Annandale describes in his three forms as the clitellum. It must always be dangerous to draw conclusions on *à priori* grounds by arguing from one form to another, however closely related; and I feel that my temerity is especially great when these conclusions conflict with the interpretations given by Dr. Annandale after his examination of the forms themselves. But I cannot help thinking that the appearances described and figured in his two papers as the clitellum of his three species are the same as those I have called the zones of budding; and that the clitellum is really the site of a future division of the animal, and is not concerned with sexual reproduction in any way.

Reference to Annandale's figures, and a comparison with those given in the present paper and those previously given in the account of *C. punjabensis*, will show that the clitellum corresponds in position to one of the sites of future division. Thus the clitellum is stated to occupy the tenth and eleventh segments in *C. bengalensis*; the figure of this species, which shows the clitellum as being behind the setæ of segment 10, may be compared with the anterior half of the as yet undivided animal shown in fig. 5 of the

[1] Not strictly in the case of *C. bengalensis*, in which the setæ of the ninth segment also come into relation with the stomach; unless indeed (which I think possible) a second, less permanent, constriction towards the posterior end of the stomach in this form represents the division between stomach and intestine in the others; the relations of the setal bundles to the divisions of the alimentary tract would then be identical throughout.

present paper; they differ only in the fact of an extra, newly-developed group of setæ in front of the constricted zone in the latter specimen; or, if the figure of *C. bengalensis* is compared with the posterior part of fig. 5, the correspondence is only incomplete as regards the number of segments at the posterior end of the animal. Similarly the figure of *C. bengalensis* resembles the anterior half of fig. 7 of the present paper, with this difference, that very minute new setæ are beginning to form in the region under discussion in the latter.

The figures of *C. spongillæ* and *C. sp.* in Annandale's second paper may be compared with the present fig. 4; the bud in fig. 4 shows a few more segments than the buds in Annandale's figures, the clitellum, however, corresponds to the lateral expansion of the nerve-cord behind the eighth segment in fig. 4; the length of the interval between this and the next and more prominent constriction appears to be two fully developed segments in *C. spongillæ*, three in fig. 4, four in *C. sp.*

The nature of the change at this region also appears to correspond; the clitellum is not a specially protuberant region, as in other Naididæ, but appears to be somewhat, if only slightly, constricted, and the figures appear to give evidence of a slight superficial transverse wrinkling of the skin. This is comparable with what occurs at this situation in *C. pellucidus*. In Annandale's figures, again, the alimentary tract is somewhat blurred and indefinite at this region; I have found this to be the case on account of the lateral upgrowths of nervous matter, and also because of a closer connection between the tract and the body-wall.

The statement that the clitellum exists even in young animals just separated (in *C. bengalensis*) may be compared with what was stated above, that even the youngest free animal (*cf.* text-fig. 2 and pl. x, fig. 3) shows the commencement of formation of a zone of budding behind the eighth segment. The fact that the clitellum is achætous may be explained by a reference to fig. 7; the extremely minute newly developing setæ of this specimen would have been absent had it been examined a little earlier, and would not have been detected as it was, had not a high magnification been employed.

I have not, even in the sexual animal, noted a clitellum; the zone of budding, the nature of which is evident, occurs however in the same place. But I wish to guard against saying that a clitellum does not occur; it probably develops later; in *Nais* and *Pristina*, according to my observations, it is not present until the genital products are far more conspicuous than they are in the sexual *Chætogaster* above described. And I would mention, in conclusion, that the Limicolæ have (so far as known) the clitellum on the genital segments themselves; a clitellum in *Chætogaster* on the tenth and eleventh segments would be much posterior to the genital segments.

The above comparisons seem to me to show that the structures described by Dr. Annandale and myself in different ways are really

the same thing; and if I am justified in interpreting his figures in the above manner we have, probably, throughout the Indian species, the development of a zone of budding behind the eighth segment, and consequently a normal length for the animal somewhat greater than this, though separation may be delayed and the typical single individual may possibly in some species never, or hardly ever, be met with in practice.

The chief differences exhibited by the Indian forms appear to be the following: The suckers of some forms are instances of adaptation; anterior and posterior are described in *C. bengalensis*, anterior only in *C. spongillæ*. The number of setæ in a bundle is greater in *C. bengalensis* than in the other forms. The first pair of nephridia are larger than the others in *C. bengalensis* and *C. sp.*; the first nephridium appears to be in the sixth segment in *C. bengalensis*, in the seventh in the others (not mentioned in the account of *C. spongillæ*). The nerve ganglia of *C. bengalensis* and *C. spongillæ* are described as being of a discrete nature, not corresponding in arrangement with the segmentation of the body; while in the Punjab species the ganglia and segments correspond posteriorly at least; if in *C. pellucidus* the lateral branches of the anterior portion of the cord be taken to represent the number of fused ganglia, then here also we have a larger number of nervous segments than of body-segments.