ART. XXV.—*On the Composite Ascidians of the North Shore Reef.*

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Plates XXIV.–XXX.

PART I.—INTRODUCTORY.

ACROSS the harbour of Auckland to the north-east lies the North Shore suburb, and still further beyond in the same direction the volcanic island of Rangitoto rises, separated from the mainland by the channel of that name. Skirting the western shore of this channel for some few miles the cluster of rocks known as the North Shore Reef is reached: a favourite collecting-ground for the zoologist, and one which has already provided much interesting material for the student of our New Zealand fauna. These rocks, only a few acres in extent at the most, are quite submerged at ordinary high tides, and, except at low spring-tides, are separated from the beach by a shallow stream of no very great width. The numerous pools left at low tides, protected as they are from the violence of the waves by the outlying barriers, afford a congenial home to many of the lesser denizens of the deep. Two fields of research, at present almost, if not quite, unexplored, here offer themselves: first, the sponges, of which great numbers may be distinguished; and, secondly, the Composite Ascidians, with some of which this paper deals.

I have, for the sake of convenience, divided my subject into three parts. The first is purely introductory, and deals with the subject in its more experimental aspect, discussing the methods employed, the means available, and matters of a similar nature. The second will deal with the anatomy and histology of the various species, as far as I have been able to elucidate them. The third will then summarise the facts noted previously, and deduce therefrom any conclusions of importance such as may be, in my opinion, warrantable.

The first visit to the collecting-ground was made early in the month of July, in company with Professor Thomas, when, owing to the rapidly-rising tide, nothing was done beyond gaining a practical knowledge of the locality. A second visit, a fortnight later, resulted in my securing five distinct species.* Of these

* *Leptoclinum niveum*, *L. densum*, *L. tuberatum*, *Cystodytes perspicuus*, and *Polysyncraton paradoxum*.

five, two* could not afterwards be obtained, despite my endeavour. These forms were killed by immersion in 60-per-cent. spirit, and afterwards hardened in alcohol of various grades up to 86 per cent.: a course of treatment which gave excellent results despite its primitive character. A subsequent visit in the month of September gave three new species† (and several varieties which lack of time prevented me from fully examining), in addition to the duplicates of the earlier collection. These were all removed to the laboratory in their native element, and, after careful observation in the living condition, were killed, some by osmic acid, others by the slow spirit method (Elsig's), and others by picro-sulphuric acid. As far as the materials would allow, each species was treated in all three ways: where the colony was too small to divide, the slow spirit killing was followed, as its greater simplicity involved less risk. Good results were, however, obtained in all cases.

For staining purposes picro- and borax-carmine were chiefly employed, both being used in every case except the osmic-acid specimens, which were transferred directly to picro-carmine. The picro-carmine was used for staining the "corm" or "ascidiarium" in its entirety before imbedding and sectioning. Other subjects, previously imbedded and sectioned, were either mounted in the natural condition or stained in borax-carmine or iodine. The picro-carmine staining proved much superior under the microscope, as it gives greater differentiation in tint, and is more transparent.

It was found necessary to decalcify the three species of *Leptoclinum*—*L. niveum*, *L. densum*, and *L. tuberatum*—before any satisfactory examination could be made. This was accomplished by the use of a weak solution of hydrochloric acid in 86-per-cent. spirit, the acid being added drop by drop till small bubbles of gas began to rise, fresh acid being added when the effect of the first was neutralised. In this way decalcification took place slowly and gently with the least possible injury to the tissues. The results were, in each case, excellent. Specimens so treated were, after the removal of all traces of acid, stained and mounted in the usual way.

Sections were made both longitudinally and transversely to the axes of the zooids, or, more properly speaking, parallel and at right-angles to the surface of the colony, since the zooids are seldom arranged quite perpendicularly to the exterior boundary of the test. In all cases the sections were taken by hand. *Cystodytes aucklandicus*, on account of its larger size and the opacity of its mantle, was prepared by saturation with paraffin, &c., for sectioning in the rocking

* *C. perspicuus* and *P. paradoxum*.
† *C. aucklandicus*, *P. fuscum*, and *L. maculatum*.

microtome, but time did not permit the completion of my intention. This is all the more to be regretted in this case as the accounts of the genus available are very meagre, and the complete examination I was able to make of the test proves in our New Zealand forms a remarkable amount of speciality, which might possibly be reproduced in the internal structure.

Canada balsam and glycerine were used as mounting media—chiefly the former, though in many particulars glycerine excels, as in the case of *Cystodytes*. Wherever any special mode of treatment gave desirable results the fact will be specified in the second part of my paper, so that any lengthened mention here is out of place.

For microscopical examination, a Crouch's student's microscope, with eyepiece 3 and Zeiss's *a** objective, was used for low powers, being useful chiefly in the case of *Cystodytes*. In all other cases a Zeiss instrument with oc. 2 and objectives A, C, E, and F was employed, every part of each section being carefully examined with obj. A, and details referred to the higher powers when necessary. As some hundreds of sections containing thousands of zooids were thus passed under review, the work was naturally tedious, but none the less interesting, and, I hope, profitable.

Drawings were made of all the species, the accompanying plates being so designed as to show all points of interest as far as possible. I believe that these plates, with their accompanying explanatory notes, will speak for themselves as to their mode of production: here, however, I may briefly state that drawings of the colony in complete section were, unless otherwise specified, made from the sections directly, using obj. A. The thickness of the colony at the point of section was carefully determined by a millimetre scale, and the drawing afterwards copied, using the scale to determine the amount of enlargement. Thus, *Cystodytes aucklandicus* measures exactly 5mm. in section naturally: the fig. (1 in Pl. XXX.) is enlarged 7 diameters. In some few instances the drawings have been made without much attention to scale, but generally an attempt has been made to so use the camera that a fair comparative test of the corresponding parts in different species may be arrived at. To this end a drawing-table was placed by the side of the microscope, and thus the distance traversed by rays of light was in all cases the same, the height of the table being constant, and such as to reduce the outlines to a suitable size. Each figure has an explanatory note giving the objective used, and stating whether the camera was employed or otherwise. A Zeiss's "Abbé" camera was the instrument thus used.

It only remains for me to notice the works of reference available. These are not numerous, nor can I suppose that my species will in all cases be found to be new, as I have had no access to most of the works dealing with the subject. Such as I have had, however, lead me to conclude that our New Zealand forms are all peculiar; but of this more must be said later on. Of general works on zoology, such authors as Rolleston ("Forms of Animal Life"), Huxley ("Anatomy of Invertebrata"), Claus ("Zoology"), were all that I had to depend upon: very little could, however, be derived from thence. More important in every sense are the papers by Professor Herdman on the Tunicata found during the "Challenger" expedition (vol. vi., pt. xvii., and vol. xiv., pt. xxxviii.). The latter deals, on the whole, exhaustively with the "Challenger" species, though incomplete in some particulars, and is of still higher value on account of the amount of information it affords with regard to general anatomical details and to classification. The latter, especially to a beginner, presents features of very great difficulty, and I must here premise that my nomenclature is merely provisional, being designed rather to serve as a convenience for reference than to remain unchallenged in the scientific world.

Three distinct genera are represented in the North Shore forms, their generic affinity being quite beyond doubt. The genus *Cystodytes*, von Drasche, is represented by two forms, which, added to the five known species, gives a total of seven. Herdman places this genus among the Distomidæ. Four New Zealand species are referable to Milne-Edwards's genus *Leptoclinum*, as also are a number of varieties, thus further extending this large family in distribution, if not in number of species. Lastly, two closely-allied but quite peculiar forms are found, which I place provisionally in a new genus, *Polysyncraton*. As to the family relationship of the latter genus, I may here remark that it is the most interesting point offered for consideration by our Composite Ascidians: further discussion may be postponed till their description is completed.

Part II.—Anatomical and Histological.

Family DIDEMNIDÆ.

Genus Leptoclinum, Milne-Edwards.

Leptoclinum niveum, n. sp. Plate XXIV.

Small colonies of this form were obtained both in July and September.

The colony is usually of small extent, the thickness varying from 1mm. to 2mm., and closely incrusts the loose stones lying about the reef, being met with only on the under-surface. It is readily distinguishable from the other three New Zealand species by its pure dense-white colour and uniform texture of surface. The position of the zooids can only faintly be recognised by a slight greyish tinge above the body of the animal. The arrangement is irregular.

The branchial pores are extremely small, and are in most instances quite indistinct. In specimens killed by Elsig's method they are visible as faint dots on the white ground, but in all other instances are inconspicuous till highly magnified. As seen in transverse section under the microscope, the aperture (fig. 5) appears faintly trilobed, the branchial siphon (*br.s.*) being quite plain-edged. A well-marked branchial sphincter (*sph.*) surrounds the anterior end of the siphon. The mantle has separated from the test in fig. 5, the limit of the latter being seen as a faint ring (*t.l.*).

The common cloacal openings are small and indistinct, none being seen on taking a surface-view, though met with at rare intervals in longitudinal sections. Cloacal canals are well developed in the upper layer of the test (fig. 2, *c.c.*), and numerous canals of large extent are also present in the lower layer below the zooids, communicating in many cases with the cloacal canals by large passages. These lower canals in some cases open on the under-surface of the colony (fig. 2), where the great accumulation of fæcal pellets suggests their acting as common cloacal openings.

The spicules (fig. 8) are fairly large, with sharply-pointed rays varying somewhat in number and size. In distribution (fig. 1) they are very numerous on the upper surface, and only slightly less numerous through the remainder of the test. Each is enclosed in a delicate membrane, which stains slightly, in decalcified sections, with borax-carmine.

Histologically, the test shows very numerous test-cells, which stain deeply with carmine. They are rather smaller and more numerous in the upper layer of the test, fewer and larger below. Under a high power (E) they are distinctly nucleated, and exhibit delicate fibrils, which sometimes anastomose (fig. 6). No bladder-cells are met with.

Test-vessels, in the form of vascular prolongations of the mantle, are frequently met with, being sometimes furnished with a terminal knob. Usually long and filamentous, they can be here and there traced up to their point of origin from the œsophageal region (fig. 2, *v.ap.*).

The zooids are small, and very distinctly separated into the so-called "thorax" and "abdomen" by a peculiar œsophageal constriction (fig. 2, *œ.c.*) just above the abdominal portion of the œsophagus, and below the vascular appendage. The abdomen slightly exceeds the thorax in size (fig. 10), and in decalcified specimens is usually found to have shrunk away from the wall of its test-cavity, leaving the mantle-epithelium and connective tissue of the mantle round the zooid, while the mantle-ectoderm (fig. 4, *m.e.*) is still attached to the test.

Fig. 4, from a specimen treated with osmic acid, also shows faintly the squamose epithelial cells in outline (*m.*).

As before mentioned, the branchial siphon is plain-edged, and widens gradually, ending in the muscular ring from which the numerous tentacles spring (fig. 4, *b.t.*). The tentacles are all of equal length, their points meeting across the buccal cavity.

The normal four rows of branchial stigmata are present, most clearly distinguishable in the young zooid (fig. 10) on account of the greater opacity of the mantle in the adult stages. Still, four rows were distinctly traceable in the mature zooid, the cilia fringing them being faintly seen. A row of large "fringing cells" (fig. 9, *f.c.*) outline the stigmata very clearly, and also indicate the limit of the longitudinal vessels (*l.v.*, fig. 9). The transverse vessels (*t.v.*) are much broader than the longitudinal. The fringing cells have large oval nuclei, which stain deeply, especially with picro-carmine. Other deeply-stained nuclei are also found (fig. 9, *nc.*) over the branchial vessels: these no doubt indicate the cellular structure of the branchial basket.

The endostyle (figs. 2, 4, and 10, *en.*) is large and distinct. In transverse section it appears square, and with obj. C the columnar epithelial cells can be discerned (fig. 4, *en.*). Its course is very undulating (fig. 2, *en.*), ceasing indistinctly near the œsophagus. When viewed from below, as in fig. 2, a clearer space appears in the centre: this is due to the fact that the epithelial cells here are not piled upon each other, being viewed endways only.

The dorsal lamina is represented by a series of long languets, situated transversely on the transverse vessels of the branchial sac (fig. 9, *d.l.*). They are broad at the base, and flattened, the edges being fringed by large cells distinctly outlined. (See note on peripharyngeal band at end of description.)

A small nerve ganglion (*n.*) and larger neural gland (*n.g.*) are seen in all transverse sections through the upper region of the branchial sac (figs. 4, *n.* and *n.g.*, and 10, *n.*).

The alimentary system is remarkably complex, and appears to offer peculiarities hitherto unrecognised. The œsophagus, after narrowing greatly at the œsophageal constriction (*œ.c.*, fig. 2), widens again, and passes soon into the cardiac division of the stomach, which is large and thick-walled (fig. 7, *st.*). In longitudinal section the stomach has a bobbin-shaped lumen (Pl. XXIX., fig. 8), and is seen to exhibit traces of columnar epithelial cells of great length composing its walls. The stomach is then continued as a pyloric sac about equal to the œsophagus in size where it leaves the stomach, but dilating distally into a bulb, in many instances, before passing through a narrow pyloric constriction into the short much-swollen intestine (fig. 7, *i.*, and fig. 2, *p.b.*). Through a second constriction the rectum is reached: this in its earlier course is largely dilated (fig. 7, *r.*) and glandular. It turns out of the plane passing vertically through œsophagus, stomach, and intestine slightly to the left, then recurves sharply as a transparent membranous tube surrounding the dark fæcal pellets to the right side of the œsophagus, round which it passes dorsally, and thence makes its exit through the œsophageal constriction. The atrial pore is seemingly plain, showing neither lobes nor languets (fig. 10, *a.p.*). Glands are present chiefly on the pyloric bulb of the stomach, where they have the form of large homogeneous cells, strongly refractive and giving the bulb a somewhat crenated appearance in its outline.

Reproduction appears to be effected chiefly by gemmation of the type called "pyloric" (fig. 10). In all cases where gemmation was observed the young zooid had exactly the position with respect to its parent figured in Plate XXIV., the dorsal surface of the former being applied closely to the ventral (endostylic) surface of the latter.

The testis consists of a single large pyriform mass, granular in appearance and deeply stained, surrounded at a varying distance by a delicate transparent membrane. The "stalk" of this mass connects with the vas deferens, which is strongly defined, and coils eight or nine times around the membranous testicular investment before springing up to pass through the œsophagus (fig. 10, *v.d.*).

A single large nucleated body, of opaque homogeneous appearance, lies near the intestine and testis in many zooids from colonies obtained in September. These I take to be ova (fig. 10, *ov.*).

NOTE.—All notice of the peripharyngeal band is omitted in the above account. It is present as a circlet of deeply-stained cells passing around the thorax on its inner surface, between the buccal tentacles and the branchial basket. Ventrally it unites with the commencement of the endostyle, while dorsally it is hollowed to receive the nerve ganglion (fig. 3, *pp.b.*). This band is the point from which the mantle (epithelial and connective-tissue layers) separate clearly from the body-wall; the mantle-ectoderm is represented by the lining of the test-cavity (*m.e.*).

Leptoclinum densum, n. sp. Plate XXV.

Colonies of large size were obtained on each visit for purposes of collection.

The corm is an incrusting mass varying in thickness from 1·2mm. to 4mm. In some cases the edge of a colony leaves the object of attachment, and, growing freely for some time, turns over upon itself, thus forming a double layer, reaching a thickness of 6mm. The surface is compact and minutely granular; colour varying from light-pink to a yellowish-red. Zooids quite inconspicuous and irregularly arranged.

The branchial pores are very small and indistinct. In transverse section the branchial siphon has its edge six-lobed, the lobes turning outwards (fig. 4). Inside the branchial aperture is seen closed as in *L. niveum* by three lobes, much fainter and less granular, however. The branchial sphincter is well developed in longitudinal sections.

Common cloacal openings are small and invisible without high magnification (fig. 1, *c.c.o.*). Cloacal canals are distinct even when the spicules are present (figs. 1 and 2, *c.c.*). These canals are near the surface, and, as far as present observations extend, never connect with downward passages, lower canals being also absent.

The spicules (fig. 6) are remarkable, being equal in size to those of *L. niveum*, but much denser, the rays having their ends in all cases rounded instead of pointed. They are extremely numerous, far more so than in the preceding species, and are most abundant on the upper surface and in a thin layer running parallel to the lower surface at some slight distance above it (fig. 2). Their number is so great that examination is quite impossible except in decalcified specimens, and they give a characteristic brittleness to the corm both in the natural state and in alcohol-hardened specimens. Each spicule is faintly pink in the stained sections—the only case in which colour is present. As only osmic-acid specimens were mounted without previous decalcification, I am inclined to think that the colour of the colony is due to this coloration of the spicular membrane, the colour being in other preparations removed by the alcohol employed. Specimens of *L. niveum*, also treated with osmic acid, showed no such coloration. No sections in the natural state were available after the discovery was made, otherwise the point might easily be settled.

The test differs considerably from that of *L. niveum* in its histological structure, The test-cells are far more numerous and smaller (fig. 3, *t.c.*). They are embedded in a structureless matrix, which, on careful focussing, reveals numerous clear spaces of polygonal or rounded form, separated from the matrix by a very delicate membrane. This I take to be the spicular membrane (fig. 3, *sp.m.*). The same characters are presented throughout the test, except that these spicular membranes are smaller and more numerous where the spicules are most strongly developed.

Test-vessels are present (fig. 1, *v.ap.*), in this case uniformly taking their rise near the termination of the endostyle. A terminal knob is usually present (fig. 7, *v.ap.*).

The zooids slightly exceed in length those of *L. niveum*, but show the same peculiar œsophageal constriction (fig. 7, *œ.c.*). The thorax is much smaller than in the preceding form: the abdomen is nearly equal in size in each.

The branchial siphon (fig. 5) is long and much dilated above. Its edges exhibit six lobes of small size. The mantle-ectoderm surrounding it shows very distinct nuclei. The buccal tentacles are sixteen in number, and even in length; their ends being pointed.

The branchial basket generally exhibits the same features as *L. niveum,* except that everything is proportionately reduced owing to the smaller size of the thorax.

The endostyle (fig. 5, *en.*) is remarkable for the upward extension of its pointed conical end above the muscular buccal ring from which the tentacles hang. Its course is a recapitulation in other respects of that of the previous species. The dorsal lamina also offers no distinctive features.

Nervous centres were frequently visible in many zooids as opaque bodies situated on the dorsal body-surface (fig. 7, *n.*). None were seen in transverse section.

The peripharyngeal band (fig. 5, *pp.b.*) is distinctly visible below the circle of tentacles, its connection with the endostyle being also distinct. The commencement of the peribranchial cavity at this point is also very noticeable, though visible only in zooids whose thorax has been longitudinally slit.

The alimentary tract exhibits no traces of a pyloric bulb, but a well-marked pyloric constriction divides the intestine from the stomach. The rectum is not distinctly coiled round the œsophagus as in *L. niveum* (fig. 7), but probably repeats an analogous curvature nearer the œsophageal constriction. The atrial pore is plain.

No instances of gemmation were observed, but sexual reproduction appears to be common, judging from the number of tailed larvæ present in the colonies found.

A curious feature in the testis was observed in some three or four cases, and may possibly be normal. The single vesicle characteristic of the family appeared split in two. The investing membrane surrounds both the closely-applied masses (fig. 8), and the vas deferens coils spirally around it some seven or eight times. The testis is near the intestinal loop, and usually on its right side (fig. 7).

Hard by the testis opaque bodies distinctly nucleated were observed in all colonies, greatly resembling those found in *L. niveum.* Only one was present in each zooid where they were found, and from many they are absent altogether. Similar bodies are present in the lower layer of the test in considerable numbers (fig. 9, *ov.*). They are of large dimensions, being often nearly equal to the testis in size (fig. 7, *v.d.* and *ov.*; and fig. 8, *ov.*).

The lower layer of the colony also presents numerous tailed larvæ in various stages of development. A somewhat early stage is figured in fig. 9, *l.*, close by the ovum (*ov.*). Fig. 10 shows an older larva in which the number of adhering papillæ is four, three being apparently the usual complement as in fig. 11. Two distinct pigment-spots are present in each case—an anterior, small and rounded; and an irregularly triangular posterior of larger size. These are undoubtedly sense-organs, and probably are eye and auditory organ respectively.

Leptoclinum tuberatum, n. sp. Plate XXVI.

Several colonies were obtained on both occasions. On the first visit, however, all were distinctly alike; those got subsequently differ much in colour, though, as far as I have been able to examine them at all, they are not otherwise distinct.

The type form is an incrusting mass of small thickness, 0·8mm. to 1·5mm., and of a white colour, slightly more greyish than *L. niveum*, from which it is readily distinguishable by its stellate appearance at intervals on the surface. On using a lens these starlike features become still more pronounced, and indicate the position of the zooids, which are arranged in irregular rows.

The branchial pores are large and stellate, there being six lobes of the test projecting radially into each (fig. 3). Under a high power the apertures are seen to correspond with these lobes, the six rays being however very irregular. No common cloacal apertures were observed. But cloacal canals are very largely developed (fig. 2).

The spicules vary much in size and in the number of their rays (fig. 4). They are always sharp-pointed. They are most numerous in the true surface-layer, and in the second surface-layer (fig. 1), which cuts the base of the endostyle. They are much more numerous between the zooids than above them in the superficial layer, giving the transverse sections the appearance illustrated in fig. 3.

The test histologically is characterized by its possession of extremely numerous test-cells, these being smaller and more numerous than in either of the preceding species. But in its more general features the present form diverges very greatly from all others of which I possess any account. The extreme superficial layer is thrown up into numerous small papillæ (figs. 1 and 2), the spicules being absent, thus leaving a delicate transparent membrane over the firmer portion of the colony. Around each zooid the test is very thin, and shows only a few spicules (fig. 1), except at two points right and left, where a projection of the test-matrix is found containing enormous quantities of small spicules (fig. 1, *ph.t.*). These "pharyngeal tubercles" are very frequently, though seemingly not always, met with. Between the zooids there extends usually a wide and deep cavity, arched above, but flat below, where a second layer of test parallel to the surface runs, as said above, along the colony at about the level of the œsophagus (fig. 1). The drawing (fig. 1) gives the arrangement actually seen in very many cases, which is, however, by no means universal (see fig. 2 for comparison). Beneath the second layer the test is compact, and has cavities only for the zooids and developing embryos.

Vascular appendages are uniformly present, springing from the region above the œsophageal constriction (fig. 2, *v.ap.*). They do not usually end in terminal vessels.

The zooids are remarkable for their greatly elongated thoracic region (figs. 2 and 7), and long extension of the œsophagus above its constriction.

The branchial siphon (fig. 5, and fig. 7, *b.s.*) is comparatively short, and quite narrow in spite of the large size of the stellate opening. As seen in longitudinal section it presents the form shown in fig. 5, the test-matrix containing spicules, &c., being projected downwards in the form of triangular lobes around the upper edges. The buccal tentacles are few in number, and of two sizes, all much shorter than in *L. niveum* or *L. densum*. Their ends are rounded, and not pointed.

The branchial basket is of extreme delicacy, the mantle being quite transparent usually. Owing to the vacuolated character of the test in the pharyngeal layer the zooids are usually much displaced and contorted, rendering observation as to details difficult. I have, however, succeeded in obtaining a good detail figure (fig. 6) for comparison. The stigmata are long and narrow, the fringing cells being convex and distinctly outlined on the stigmatic, but straight and faintly marked off on the vascular, surfaces. The large oval nuclei lie near the vascular border. Cilia are only faintly distinguishable. The transverse vessels are plain, and scarcely wider than the longitudinal. Only three rows of stigmata are observable in the adult, but four are always present in the young form (fig. 7).

The endostyle offers no peculiarities; it is always distinct and very undulating in outline (fig. 1, *en.*). The dorsal lamina is represented by a series of very long languets, broad at the base, but pointed distally (fig. 6, *d.l.*). More remarkable is the fact that the stigmata on either side are scarcely more widely disparted than in the remainder of the pharyngeal basket.

The peripharyngeal band is usually very distinct as a broad circlet of deeply-stained cells below the buccal tentacles (fig. 5, *pp.b.*).

The alimentary tract is distinctive, approaching the form observed in many other species more closely than that of its New Zealand allies. The stomach is large, and has walls formed of long columnar cells (fig. 7, *st.*). It communicates by a short unconstricted pyloric tube with the intestine, which is thick-walled and globular (fig. 7, *i.*). A short narrow passage leads into the dilated rectum, which is glandular in its lower half, and above encircles the œsophagus (*cf.* fig. 7 with Pl. XXIV., fig. 7). The atrial pore is plain (fig. 7, *at.p.*), and, as in other Leptoclinids, situated half-way up the branchial basket.

Reproduction by gemmation is of frequent occurrence, and is an exact counterpart of the process seen in *L. niveum* (fig. 7). In fig. 7 a young zooid is shown with stigmata, languets, and atrial pore plainly visible.

The testis presents the form characteristic of the family, there being usually only five or six coils of the vas deferens. Its position varies much with the shape of the abdominal cavity. Generally near the intestine, it may occasionally be found in contact with the rectum in a special test-chamber (fig. 1, *v.d.*).

Opaque rounded bodies supposed to be ova were met with in the test, also a few tailed larvæ (fig. 8). These are distinguishable at once from those of other species by the enormously long tail, which quite encircles the body. Two pigmented sense-organs (eye and auditory sac) were always present, also three adhering papillæ (*s.o.* and *a.p.*, fig. 8).

Leptoclinum maculatum, n. sp. Plate XXVII.

A single colony of small extent was obtained in September.

The corm varies in thickness from 1·5mm. to 2·5mm. In colour it is a light-brown, spotted with dull white above the zooids, which thus become very conspicuous for a Leptoclinid. In consistency the colony is firm and leathery, but tears easily, and adheres very closely to the rock.

The branchial pores are smaller than in any other species examined, but in the living condition can be discerned with a lens under favourable conditions. A high power used on surface-sections shows the pore to be six-lobed, but three of these lobes are very small, and wedged in the angles of the others in such a way as to create the impression that only three large lobes exist (fig. 4).

Common cloacal openings are few in number and large, though not distinct. In fig. 2 one is shown in section (*c.c.o.*), the edges being apparently lobed. Much irregularity is, however, observable, and this appearance I look upon as accidental. Cloacal canals are well developed.

The spicules are extremely small, and vary much in size (fig. 3). On a surface-view they appear most numerous around the branchial pore (fig. 4), being absent in the intervals. In longitudinal sections a layer occurs at the level of the buccal tentacles, which is fairly well supplied with spicules, most numerous round the zooid. In the lower layers they are few or quite absent (fig. 2), being met with principally near the œsophageal constriction.

Histologically, the test exhibits a structureless matrix, with very numerous nucleated test-cells throughout. The surface layer is characterized by its large oval bladder-cells (fig. 5), which, with borax-carmine, appear finely granular, nuclei being often visible in the walls (fig. 5, *nc.*). These cells are also met with rarely in the lower parts of the test.

Vacuoles (fig. 2, *v.*) of large size occur below and among the abdominal prolongations of the zooids. In some few instances these unite with the cloacal canals (*c.c.*). The thoracic region of the test also shows irregularly-quadrilateral chambers and passages, recalling those of *L. tuberatum*, as shown in fig. 2. This arrangement is, however, quite unusual, the rule being for the test to be perforated with wide cloacal canals, which here and there enlarge greatly.

Ectodermal prolongations of the mantle are of frequent occurrence, usually ending in a bulb (fig. 1, *v.ap.*).

The zooids are much elongated, occupying a relatively deeper layer of the test than in the former species considered. Most remarkable is the great length of the œsophago-rectal region, which with its mantle envelope often exceeds by one-half the length of the thorax. This region is also, in many cases (fig. 2), continued below the constriction (which is always very definite) for some distance before the abdominal dilatation commences.

The branchial siphon is of considerable length (figs. 1 and 2, *b.s.*), and of remarkable form. The edge (branchial pore) is quite plain. For some distance the siphon is fairly even in size; it then dilates greatly, forming a bottle-shaped mass (fig. 8, *b.d.*), constricting once more slightly at the muscular band from which the tentacles arise. It thus resembles a water-bottle. In fig. 8 the mantle ectoderm is shown at a slight distance. The buccal tentacles (fig. 7, *b.t.*, and fig. 8) are long and numerous. In every case the branchial pore is found occupying a depression in the surface (figs. 1 and 2).

Four rows of branchial stigmata are present: in every case they are indistinguishable in the adult except in cross-sections. The young zooids show four rows, with apparently five in each row (fig. 6, *b.st.*).

As seen in section the endostyle is peculiar. It shows an internal cavity of large size, from which arise several smaller cavities (six in number), the outer surface being thrown up into corresponding folds (fig. 7, *en.*). The peripharyngeal band is very distinct, and is seen in fig. 7 as *ph.w.* (pharynx-wall). It is faintly visible in the young zooid (fig. 6).

The dorsal lamina is represented by a series of long languets (fig. 6, *d.l.*) arising from the transverse vessels of the branchial sac.

A small nerve ganglion (fig. 7, *n.*) and large neural gland (fig. 7, *n.g.*) are found opposite the peripharyngeal band on the dorsal surface.

The alimentary canal exhibits a return to the type found in *L. niveum.* Indeed, the only difference of moment is the absence of the pyloric dilatation met with in the former species. The œsophageal curve of the rectum is frequently displaced, being forced downwards through want of room, as shown in fig. 6. The region above the œsophageal constriction shows very clearly the rectum and œsophagus lying side by side (fig. 1, *r.* and *œ.*). As in all former cases, the lower dilated part of the rectum is distinctly glandular, being more membranous above. The atrial pore is plain.

The testis is a single mass lying near the intestine (fig. 1, *t.*), and has the vas deferens coiled nine times around it. No ova and no embryos were met with.

Family (doubtful).

Genus Polysyncraton (new).

Polysyncraton paradoxum, n. sp. Plate XXVIII.

A single colony of considerable extent was obtained in July. It was placed at once in spirit, in which it appears to be greyish-white. I have no definite recollection of its natural colour, but imagine it to be white.

The corm is a thin incrusting mass, varying from 1·2mm. to 3mm. in thickness, and is soft to the touch, tearing very easily. The surface appears more homogeneous than in the Leptoclinids examined, but slight traces of the zooids are visible in the form of darker spots. The zooids are arranged very irregularly, but much closer than is usual (see fig. 2).

The branchial pores are small, and are buried beneath the surface, so that it is almost impossible to distinguish them. The edges of the branchial siphon are faintly six-lobed.

No common cloacal openings were discovered.

Spicules are present throughout the colony; they are of fairly large size and distinctive form (fig. 3). The rays are very numerous, extremely short, and rounded at the points. Generally three or four circles of such rays are visible, gradually increasing in diameter from the centre of the spicule to its outer margin. This would indicate extreme regularity in the arrangement of the rays, as the spicule presents the same appearance from whatever point it be viewed. These spicules are evenly distributed throughout the colony, being absent only on a small portion near the surface in longitudinal sections. (Figs. 1 and 4.)

Histologically the test is distinctive. Near the surface is a thin layer of transparent matrix interspersed freely with small test-cells, whose anastomosing fibrils give a slight appearance of irregular striation (fig. 4). Below, this passes insensibly into a structure of very different aspect, the matrix being much reduced by the presence of very numerous bladder-cells, transparent and closely placed (*bl.c.*). Here, as above, the test-cells are smaller than among the Leptoclinids, but are thickly scattered through the small amount of matrix separating the bladder-cells. A few spicules (*sp.*) are also seen; but it is impossible to exactly define their position. This condition of test prevails, with slight modifications, throughout the lower layers.

A few cloacal canals of small size are observable in the test (fig. 2, *c.c.*); otherwise it is solid throughout.

The zooids (fig. 1) are small, and present features of some importance. They are distinctly divided into thorax and abdomen, but do not show any special œsophageal constriction, as met with among the Leptoclinids. The abdomen is in all cases much larger than the thorax, and far less opaque.

The branchial siphon is produced into six faint lobes at the branchial pore. It is short and fairly broad, dilating only slightly at the circlet of tentacles (fig. 1, *br.s.*, and fig. 8. *Cf.* fig. 8 with corresponding figures in other plates).

Four rows of branchial stigmata are present, and are in most cases faintly visible through the mantle. The fringing cells are very distinct (fig. 7, *f.c.*), as are also the nuclei of cells lining the branchial vessels. The transverse vessels are peculiar. A transverse lamina (fig. 7, *l.t.*) runs along the course of each, and, being of opaque nature, shuts out from view the uppermost fringing cells of the branchial stigmata immediately below. This lamina is probably muscular, as faint traces of striation are observed. The longitudinal vessels are fairly wide.

The endostyle is horse-shoe-shaped in section, and does not exhibit any traces of columnar cells. Its course is straight above and undulating below (figs. 2 and 8, *en.*). The peripharyngeal band is usually very distinct (fig. 8, *pp.b.*).

The dorsal lamina is represented by a series of languets, which are, like the buccal tentacles, short and stout (fig. 1, *d.l.*).

Nerve ganglia (*n.*) and neural glands (*n.g.*) were seen in transverse sections distinctly (fig. 8), also frequently discernible through the mantle in sections taken longitudinally.

The alimentary canal is simple. The stomach is thick-walled, the walls being columnar: its lumen is bobbin-shaped (Pl. XXIX., fig. 8). A short pyloric tube communicates with the globular intestine (fig. 1. See also fig. 8, Pl. XXIX.). A very short tube leads from the intestine to the dilated end of the rectum, which commences abruptly. For about half its length the rectum is opaque, owing to its glandular character; in the remainder it is traceable only by the numerous fæcal pellets contained. It does not appear to cross the œsophagus (fig. 1), but much variation is apparent in this particular. The atrial pore is in all cases distinct, and provided with a long languet (fig. 1, *a.l.*), which shuts against a projection of considerable size below.

The reproductive organs are striking in character. The male organs consist of a number (usually seven) of spermatic vesicles, situated near the intestine at its rectal end in such a way that their larger free ends turn towards the stomach. Each vesicle is pyriform in shape, and communicates by its small end with the vas deferens, which is very difficult to distinguish near the vesicles, but becomes exceedingly clear in its after-course. Careful focussing, however, shows on each side of the mass of sperm-bodies three small dark objects, apparently nucleated, and quite round. If observed carefully the vas deferens may be seen as a transparent thread, equal in width to the diameter of the dark bodies, and uniting them in pairs. This is the usual state, but occasionally the whole course of the vas deferens is traceable around the spermatic vesicles. It then appears to rise from the common apex of the vesicles, encircling them as a narrow transparent tube some three times, after which it dilates greatly and passes up alongside the rectum. In this part of its course it acquires a deep reddish-yellow tinge with picro-carmine (fig. 7).

Near the rectum and opposite the end of the œsophagus there lies, in a special mantle-swelling, a dark body with clear lumen, which on close scrutiny is seen to be surrounded by a ring of transparent oval bodies, differing somewhat in shape owing to pressure, and of various sizes. The dark body is composed of columnar cells, whose outlines are clearly visible (fig. 5, *ovr.*, and fig. 1). This I take to be the ovary with its ova. But if this be correct the ova are certainly not nucleated: at least, not in their present stage. No embryos were found in the colony.

A last feature, and a puzzling one, remains to be noted. This is the presence, springing from the mantle in the œsophageal region, of a large bulb, often nearly half as large as the thorax. It always arises from the side of the zooid (see fig. 2), and usually from its left side. No traces of structure were observed in any cases; it is opaque and densely granular, appearing, in fact, almost homogeneous. There is usually a

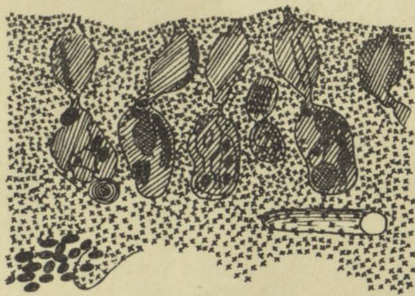

Fig 1.

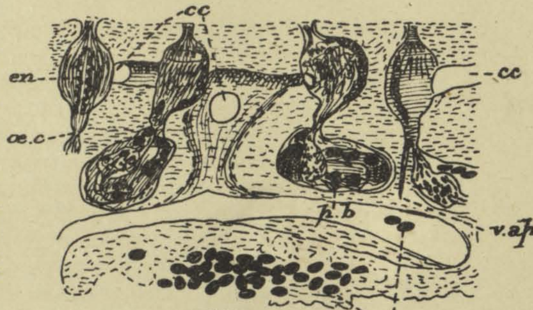

Fig 2.

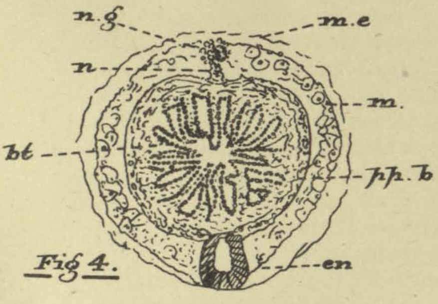

Fig 4.

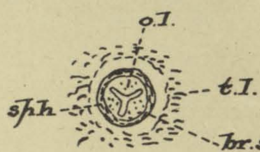

Fig 5.

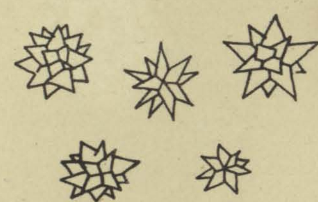

Fig 8.

Fig 6.

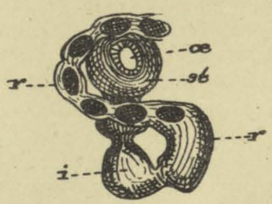

Fig 7.

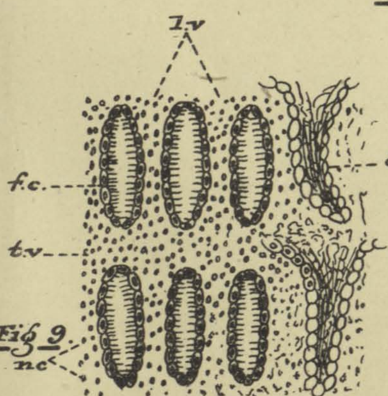

Fig 9.

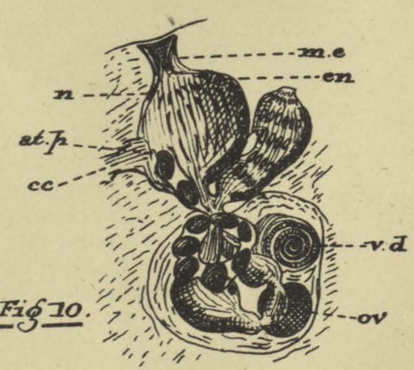

Fig 10.

J.T.N. del. N.Z. COMPOSITE ASCIDIANS. C.H.P. lith.

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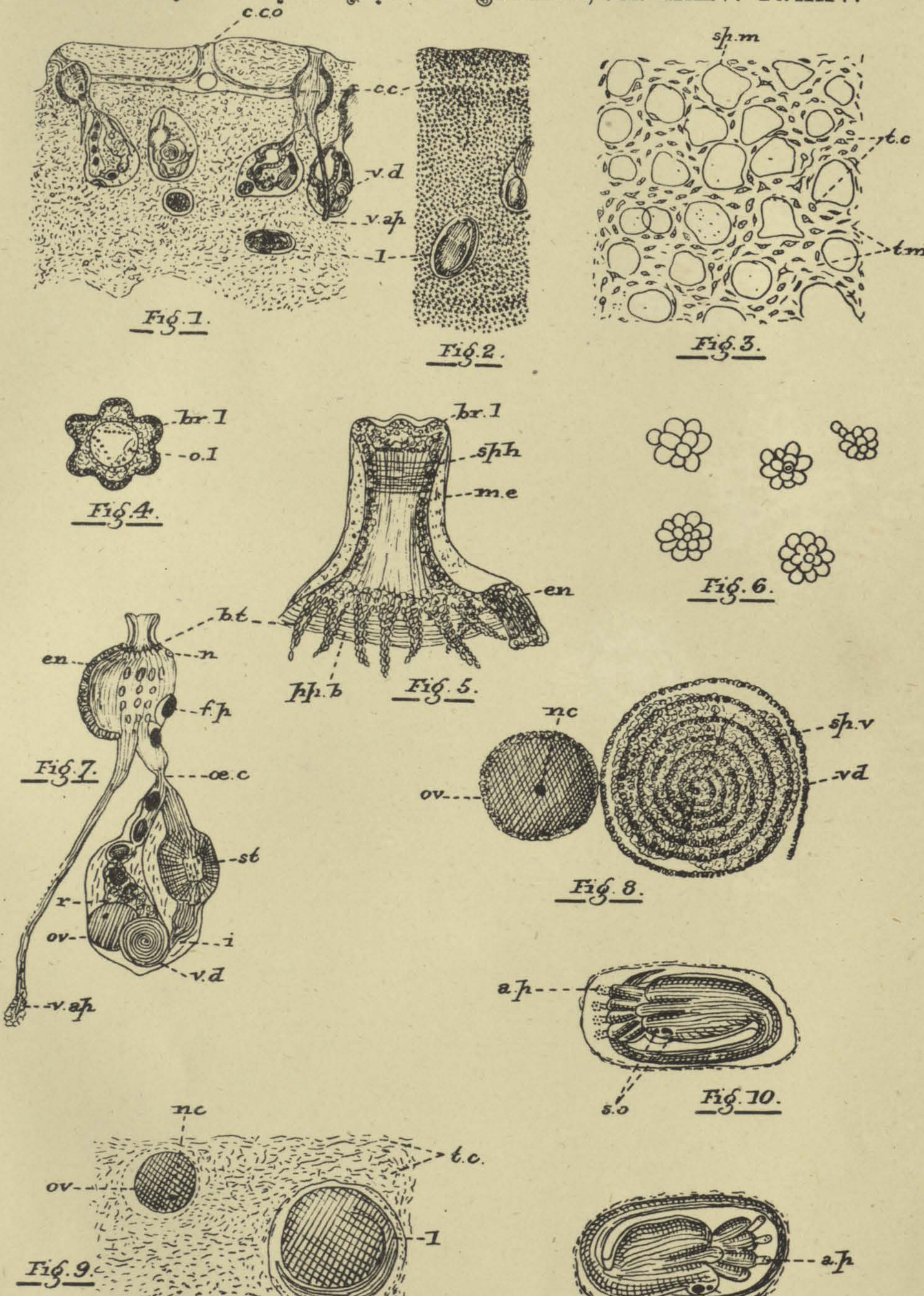

N.Z. COMPOSITE ASCIDIANS.

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J.T.N. del.

C.H.P. lith.

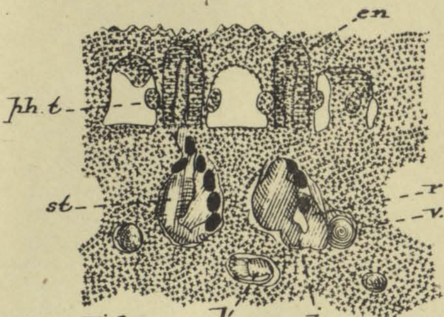


Fig. 1.

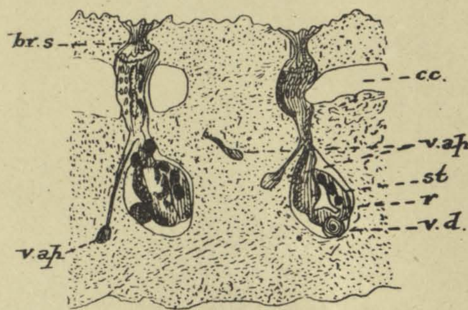


Fig. 2.

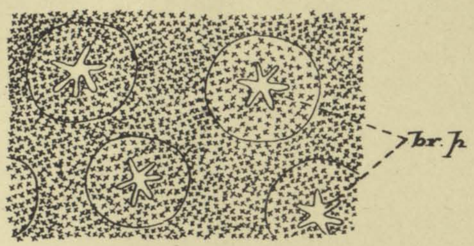


Fig. 3.

Fig. 4.

Fig. 5.

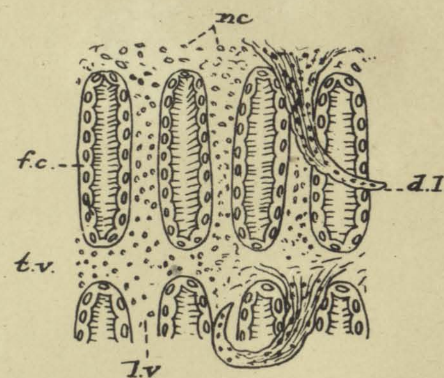


Fig. 6.

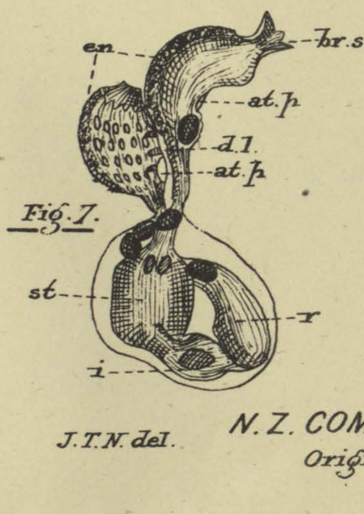


Fig. 7.

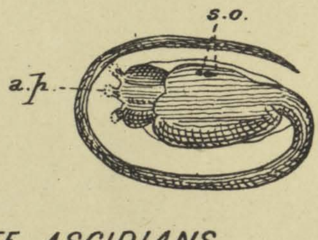


Fig. 8.

J.T.N. del.

N. Z. COMPOSITE ASCIDIANS.

Original Scale reduced 1/3.

C.H.P. lith.

small section of the distal extremity somewhat transparent, and the connecting tube is always small, and only slightly stained. My first thought was that here we had a commencing bud. But no traces of indubitable gemmation were discovered; and, moreover, even in young zooids, which had not reached the surface of the colony, these bodies were just as large and distinct as in the adult. In fact, they seem never to change. Their constancy throughout the whole of my sections, moreover, seemed to render this view untenable.

Were they highly-developed vascular appendages? This, again, seemed unlikely, for they are in all cases present only in the middle layer of the test, where the numerous zooids rendered unnecessary any such highly-developed vessels, while the lower layer, in which such prolongations usually terminate, was left vacant. Moreover, they spring from the side and not from the ventral surface as is more usual (*cf.* preceding descriptions).

Possibly it may represent a brood-pouch: but in that case its walls must be remarkably glandular; and its position is, moreover, peculiar if such be its function. In any case, no traces of ova were observed within.

For the present, then, I must leave this organ unexplained. That it has some special function of importance can scarcely be doubted; and its glandular nature, combined with its connection only with the mantle, to a certain extent may justify the term "vascular appendage" which I have applied to it in my plate, and which I retain, very unwillingly, for its provisional appellation.

Polysyncraton fuscum, n. sp. Plate XXIX.

Numerous colonies of very large extent were obtained in September.

Corm thin, fleshy and incrusting, uniform in thickness, varying from 1·5mm. to 2mm. Colour varies from deep reddish-brown to nearly black, the former colour on the whole predominating. The zooids are moderately conspicuous in position, owing to the semi-transparent nature of the test: they are not arranged in regular systems.

The branchial pores are small and not easy to distinguish: still, during life they may be discerned with a little care. The common cloacal openings, on the other hand, are very distinct, the transparent colourless outer layer of the test being raised up around them in such a way as to render them easily conspicuous. This is further aided by the cloacal canals, which ramify in all directions, as may readily be seen by the large yellow fæcal pellets within (fig. 2, *c.e.* and *c.c.o.*).

A few spicules are present, being met with only around the zooids (fig. 2). They vary extremely in size (fig. 4), but microscopically resemble those of *P. paradoxum* so closely as to require no further description here.

The test differs from *P. paradoxum* in two important points. First, the outer hyaline layer is far more extensive. Secondly, the bladder-cells are only present irregularly beneath it (fig. 7, *bl.c.*), being few in number in the layer of test above the cloacal canals, though numerous lower down. Each cell in the upper groups is oval in outline (fig. 7). Vascular appendages are common: they may be long and filamentous (fig. 1), or short and club-ended (fig. 2, *v.ap.*).

The zooids are much larger than in any species previously examined, and occupy a relatively larger amount of the common test. The abdomen is much larger than the thorax, from which it is separated by a short œsophago-rectal tube, which exhibits a slight constriction below the point of origin of the vascular appendage (figs. 1 and 2). So slight is this, however, that it can scarcely with fairness be termed a constriction.

The branchial siphon (figs. 1 and 6) has its edges faintly six-lobed. Narrowest above, it dilates gradually to the circle of tentacles, which are moderately long and of equal length. Longitudinal muscular bands (fig. 6, *l.b.m.*) run down the siphon from the oral lobes, gradually losing their distinctness till they merge in the muscular wall above the buccal tentacles. These longitudinal buccal muscles are characteristic of the species.

Four rows of stigmata are present—the branchial basket seeming to resemble that of *P. paradoxum* very closely. The lamina transversalis is, however, reduced to a mere muscular ridge.

The endostyle differs from that of its ally in being much more undulating throughout its entire length. The peripharyngeal band and nervous centre offer no theme for special comment: both are distinct. No dorsal languets were observed, but they undoubtedly exist.

The alimentary tract (fig. 8) is a repetition of that of *P. paradoxum;* the figure serves equally well for both. The upper half of the stomach has been cut away in sectioning, showing the peculiar shape of the cavity, with the passages of the œsophageal and pyloric tubes commencing. Only the glandular part of the rectum is figured. Its upper membranous portion does not cross the œsophagus, but passes out directly to the atrial pore, which is provided with a long, thick languet above and a well-marked projection below (fig. 1, *a.l.*).

The reproductive organs do not differ essentially from those of *P. paradoxum*. The testis consists of a number of spermatic vesicles, — usually seven, but ten were found in one case, —

whose products pass out by a long vas deferens, which first coils spirally four times round the mass of sperm-bodies. Its after-course is not clear as in the case of its generic relative.

The supposed ovary, which is in this case almost uniformly present, is identical in position (fig. 1, *ovr.*). But the gland itself is elongated, presenting an upper hemispherical and lower conical end (fig. 5, *ovr.*). The ova are in this species also small and transparent.

But other bodies which are undoubtedly ova are present near the vesicles in some cases. These are of large size (fig. 1, *ov.*), being equal to the intestine, and exhibit a central clearer germinal area, with a deeply-stained oval nucleus (fig. 3, *nc.*). These are probably the fully-developed ova of which the transparent bodies noted above are the originals.

One or two tailed larvæ, with a single pigment-spot and three adhering papillæ, were met with. They occupy the lower test-layer in all instances.

Family DISTOMIDÆ.

Genus CYSTODYTES, von Drasche.

Cystodytes aucklandicus, n. sp. Plate XXX.

Numerous colonies of large extent were obtained in September. It is the most numerous species met with on the reef.

Corm is moderately thick, averaging 5mm., and seldom less than 4mm. Its colour is light-brown, with darker dots where the zooids are placed. The test is fleshy and transparent, allowing the white capsules surrounding the abdominal regions of its tenants to be seen from the exterior. Over the surface runs a network of slightly lighter lines. The openings of the test, whether branchial or cloacal, are not very distinct, and are exceedingly small. There is no trace of regular systems, but not more than four or five zooids are present in each.

Great difficulty is experienced in staining. The best results are obtained from sections stained after cutting, and from sections left unstained, as the staining fluid (picro-carmine) does not readily penetrate the dense cartilaginous test. In specimens stained entire, though allowed to remain forty-eight hours in the fluid, the middle layer was only slightly tinted.

The outer test-layer is free from bladder-cells, exhibiting a structureless matrix, in which are numerous test-cells. This layer is very thin, and gives place to what at first sight appears to be simply a mass of bladder-cells throughout. Careful use of high powers, however, shows that this appearance is due to the lower cells being visible in outline through the upper. Fig. 3 gives the appearance of the test with obj. C. A test-matrix is present (*t.m.*), in which are scattered numerous nucleated test-cells of small size and with many fibrillæ. Everywhere the matrix is occupied by large bladder-cells of slightly granular appearance, and very distinctly nucleated (fig. 3, *bl.c.* and *nc.*). Towards the middle of the test the bladder-cells are not so distinct in specimens stained in their entirety, but others sectioned before staining show no difference throughout the test, except the absence of bladder-cells from the extremely thin surface-layer. In sections mounted in Canada balsam without staining the bladder-cells are scarcely visible.

The test above is broken by numerous vacuoles of large size (fig. 1, *v.*). These form vestibular chambers, into which the branchial siphons of the zooids project, the upper portions of the test being apparently never occupied by the animals. A second row of cavities occurs in the lower half of the test. These are the proper zooid capsules, the lower part —that, namely, occupied by the abdomen and upper part of the thorax—being strengthened by the large overlapping calcareous discs so characteristic of the genus (fig. 1).

Fig. 9 shows a group of these spicules seen under obj. A. They differ greatly from those figured by Herdman from the two "Challenger" species, being irregularly notched at the edges, and showing no radiating bands. On the other hand, these spicules show more affinity to those of the Leptoclinids, &c., for, if we imagine such spicules to be enormously enlarged without increasing the size of their rays, and that these small rays at the same time have their numbers multiplied greatly, we shall obtain a spherical body whose round outline will resem ,le that shown in the figure. I regard these projecting lobes as the counterpart of the rays in the Leptoclinids. In some cases the discs acquire a different appearance, illustrated in the upper right-hand member of the group in fig. 9, the closely-set rays forming concentric layers. A third spicule is shown from the edge, exhibiting its lens-shaped form.

But these spicules, remarkable as they are, do not exhaust our materials as far as the test is concerned. On the contrary, calcareous matter is so strongly characteristic of our New Zealand forms that the complete investigation of the test and its calcareous deposits alone might afford fruitful study for months.

In a few sections strong calcareous fibres (fig. 1, *c.f.*) are found in the upper layer of the test. These are extremely difficult to examine owing to their wonderful refrangibility. They appear purplish in colour with picro-carmine, but are white in the natural state, and are visible to the unassisted eye as white threads occurring at rare intervals through the colony. To light them satisfactorily in glycerine or Canada balsam is almost impossible, but, as far as I can make out their structure, they seem to be composed of smaller and more irregular spicules than those forming the capsule, fused together to form long and always straight rods, which seldom branch.

Next in interest come the peculiar deposits which I have figured in fig. 1 as *c.b.* These, again, are only local, and are best seen in unstained sections soaked for some hours in clove oil and mounted in Canada balsam. Such sections under high magnification exhibit the radiating branched calcareous skeleton shown in fig. 1, and given in detail in fig. 7. With this treatment they are extremely distinct, and are seen to be composed of immense numbers of small calcareous prisms, crystalline in appearance, and branching irregularly as in the figures.

Yet a third form must be distinguished, which is shown as *c.b.* in fig. 1, and again under obj. A in fig. 4. These "calcareous trees" are quite crystalline, and are found only in the layer of test in which the zooids are situated, being most numerous near and amongst the calcareous discs. In Canada balsam they are almost invisible, and would certainly be passed over did one not expect to find them. But glycerine preparations show them with remarkable clearness. Fig. 6 gives a detail view of one of these "trees" as seen in Canada balsam sections with obj. E.

Closely allied to these latter forms, but quite invisible in balsam, are the crystalline deposits seen in fig. 8, and found only around the zooids. Only one form was seen resembling the figure, but other crystals, reproducing exactly the small branches, are so common that the layer of test just outside the capsule seems to be composed of nothing else. They seldom exhibit more than two or three rays, and recall the form shown in fig. 4 but for their extremely small size.

Another curious detail in the account of the test is illustrated in fig. 10. This shows part of a surface view, and throws light upon the network of lighter lines mentioned above. With a high power these lines are seen to be surface vessels, distinct in outline and richly granular, being surrounded by a test-matrix in which are extremely abundant test-cells. Through the upper clear layer a few bladder-cells are visible. Here and there these vessels dilate, enclosing a dark granular body with a central darker portion, also granular. It thus resembles a nucleated cell of large size; but what is its function? This question, as well as the exact relation of the calcareous bodies above to one another and to the test, I must leave undecided, and deal briefly with the zooids.

These are of large size, and loosely attached in their capsules. The mantle is richly muscular, having distinct transverse and longitudinal muscle-bands. There is a very distinct thorax and abdomen (fig. 2).

The branchial siphon is short, and has its edge six-lobed. The tentacles were not observed, but the endostyle is extremely undulating (fig. 2, *en.*). There are four rows of stigmata, with wide transverse vessels and narrow longitudinal. The transverse vessels are slightly muscular. (Fig. 11 is from *C. perspicuus*, but the differences are slight.)

The stomach is thin-walled and globular, but not large. The relations of the various sections of the alimentary canal were not satisfactorily settled, but the course of the rectum is easily made out in zooids removed from the colony and mounted entire, by means of the fæcal pellets. There is a long atrial siphon near the anterior end of the body; its rim is also six-lobed (fig. 2, *at.s.*).

Numerous ova of varying size were found near the intestinal loop (fig. 2, *ov.*). Others were seen in special brood-pouches springing from the peribranchial cavity, and a few tailed larvæ were also met with occupying a clear transparent pouch through which the structure of the almost equally transparent embryo could be easily discerned.

NOTE.—My first conviction with respect to the calcareous matter found in this and the following species was that it could not be calcareous, for I found that in hydrochloric acid the disclike spicules dissolve readily, while the other forms do not. But on leaving a thin section in the acid (1-per-cent. solution) for five hours all traces of the deposits were removed. This anomaly I believe to be due to—(1) the different nature of the calcium crystals; and (2) the difficulty of penetrating the middle test-layer.

Cystodytes perspicuus, n. sp. (?). Plate XXX.

A single small colony was obtained in July. I am not yet convinced of its specific value, but shall consider it as such for our present purpose, and shall here merely point out the differences noted.

In external features there is considerable resemblance. But this form is slightly thinner, averaging 4mm., and is quite colourless and transparent except for the white capsules.

The spicules present no differences, but, although calcareous fibres were present, no calcareous trees were found comparable to those of *C. aucklandicus*, their place being taken by the even more peculiar crystalline forms shown in fig. 5.

Histologically the tests are identical, except as regards the calcareous deposits.

The branchial siphon is shorter than in the former species, as is also the atrial siphon. The buccal tentacles are short and blunt.

The branchial basket exhibits the same features as does that of its predecessor, but the muscular ridges of the transverse vessels are much more strongly developed.

Except the colour, no one of the above characters can be considered such as is not accountable for by simple variation. It has been seen that the calcareous elements are capricious in their distribution, if the term be appropriate to anything which we surmise to have a cause but cannot explain.

PART III.—SYSTEMATIC AND GENERAL.

It now remains for me very briefly to point out in a concluding summary the features of systematic or structural importance which the preceding descriptions appear to suggest.

Every authority upon the subject concedes the difficulty of exact classification: hence we need not be astonished to find that each new form discovered is hard to place systematically. This difficulty meets us at the outset in the forms which I assign to Milne-Edwards's genus *Leptoclinum*. Herdman ("Challenger" Rep., vol. xiv., pt. xxxviii., p. 260) sums up the features of importance in distinguishing the genera *Didemnum* (Savigny, 1816) and *Leptoclinum* (1841) as follows:—

Didemnum: Colonies thick; atrial siphon placed far back, with no languet; three rows of stigmata.

Leptoclinum: Colonies thin; atrial pore further forward, with a languet; four rows of stigmata.

Now, with one exception, our forms have four rows of stigmata, and are very thin; but no languets were noted, the atrial pore being placed in the middle of the thorax. The one exception, however (*L. tuberatum*), can scarcely be regarded as definitely settled owing to the decalcified specimens becoming much contorted in sectioning: fairly-advanced young forms always exhibit four rows of equally well developed stigmata. The thickness of a colony seems very unsatisfactory as a test of generic affinity, but, if it is to be regarded as sound, I think we must place our four Auckland species among the Leptoclinids. My own personal convictions are strongly against the generic distinctness of Milne-Edwards's group, and, as the four species here noted furnish a strong bond of connection between it and the older genus *Didemnum*, I should prefer to amalgamate the two genera under Savigny's genus.

The question of affinity to other species is also one of great difficulty. I have only the "Challenger" species to guide me, and these, owing probably to the nature of his material, are inadequately described by Herdman. Thus, in spite of the importance he attaches to the atrial pore in classification, in only one species (*L. japonicum*) does he mention it in his descriptions, and there he says, "The atrial siphon [*sic*] is placed on the dorsal edge of the thorax half-way down"! Further, he seldom mentions the alimentary tract except very briefly, and has not noticed the peculiar œsophageal constriction. I believe I am right in considering my species quite distinct from his, whatever may be their fate with regard to those of other observers.

With regard to *Cystodytes*, I have already expressed a doubt as to the specific importance of *C. perspicuus*, and tolerate it only because I feel that I do not know it well enough to reject it. But *C. aucklandicus* is so well marked by its test-structure that there is no doubt of its complete separation from both *C. draschii* and *C. philippinensis*, Herdman. The distribution of the genus (Mediterranean, Brazil, Philippines, New Zealand) probably indicates the existence of numerous species yet undiscovered, or the previous existence in geological time of connecting links now lost. Our species approximates more closely to the Brazilian form, however; though in the vacuolated character of the upper test-layer it suggests *C. philippinensis*.

Lastly, we have to deal with the anomalous genus which I have ventured to name *Polysyncraton*. Here we scarcely know which way to turn. The thin colony, the four rows of branchial stigmata, the large atrial languets, are all features which suggest the genus *Leptoclinum* as the natural home of the two species. To this also the spirally-coiling vas deferens lends strength, as does the presence of stellate spicules in the test, and the six-lobed branchial siphon. But the structure of the male reproductive bodies is exactly that discovered by Herdman in his *Cœlocormus huxleyi*, for which he founds the family Cœlocormidæ. (See "Challenger" Rep., pt. xxxviii., p. 317.) The single species composing this family also possesses stellate spicules, but the siphon is five-lobed, there are no bladder-cells in the test, and only one common cloacal aperture placed in the bottom of the cuplike colony. The curious ovary is, as far as I am aware, quite unique in *Polysyncraton*.

But in *L. densum* I have noted a tendency to division in the single spermatic mass, characteristic of the Didemnidæ. May not this be suggestive of the state of things met with in *Polysyncraton* and *Cœlocormus?* And, if so, a still stronger link between the Cœlocormidæ and Didemnidæ would be afforded by the new species, possessing as they do the corm characteristic of the latter with the form of reproductive bodies met with in the former, but also faintly foreshadowed in the latter group.

Where then must *Polysyncraton* be placed? The most obvious method of avoiding all trouble is to at once found a new family for its reception, midway between the two groups to which it is allied. But this, though easy, is open to objection, for systematic classification, at present cumbersome enough, would speedily become a scientific nuisance were every strongly-marked genus at once constituted a family.

A second course is to unite the connected families on the common ground furnished by their connection, making the spirally-coiling vas deferens, presence of stellate spicules, and double form of the body the chief characteristics of the new group. This arrangement certainly commends itself more than the former would do; but the family Diplosomidæ would still be a difficulty, though separated readily by the straight course of its vas deferens. Moreover, the corm in Herdman's family is so highly specialised that it seems quite impossible to unite it with the Didemnidæ.

A third course is open—that, namely, of enlarging the borders of some one family so as to include the new genus. Now, to unite *Polysyncraton* with *Cœlocormus* would be open to the objection urged above. To unite it to the genera placed under the Diplosomidæ would tend to confuse that family with the Didemnidæ; and to unite it with the Didemnidæ would destroy the distinctness of that group, as a Diplosomid may have two or many spermatic vesicles provided its vas deferens be straight.

A *via media* between the two latter alternatives seems best; and in this I am further encouraged by the fact that Jourdain has proposed to unite the Didemnidæ and Diplosomidæ under the title Oligosomidæ (see "Challenger" Rep., pt. xxxviii., page 307). I propose to keep the Cœlocormidæ distinct, on account of the highly-specialised ascidiarium, and to unite the genera now ranged under the Didemnidæ and Diplosomidæ with *Polysyncraton* under the single family proposed by Jourdain but disallowed by Herdman. The genera *Didemnum* and *Leptoclinum* might then form one genus, and the *Diplosomoides* and *Diplosoma* another. The genus *Encœlium* may perhaps remain distinct.

The characters of the family Oligosomidæ would then run as follows:—

Corm thin, flat, incrusting, never pedunculated.

Systems irregular or absent. Common cloacal apertures usually conspicuous.

Zooids small, and very distinctly separated into thorax and abdomen.

Test gelatinous or cartilaginous, usually containing stellate calcareous spicules. Ectodermal prolongations well developed and muscular.

Branchial siphon variable, frequently six-lobed.

Stigmata usually in four, sometimes three rows.

Atrial pore plain or with a languet.

Reproductive organs variable. Male consisting of one or more spermatic vesicles, with a vas deferens usually spirally coiled.

Gemmation pyloric.

The genus *Diplosoma* would then probably indicate the origin of the group, its few calcareous spicules and simple reproductive organs being evidence of its generalised character. From it on the one hand have arisen the species forming the genus *Didemnum*, in which the number of spermatic vesicles is reduced to one, around which the vas deferens coils spirally, and having often very numerous spicules in the test. On the other hand, the genus *Polysyncraton* has sprung from a *Diplosoma* having several spermatic vesicles and an uncoiled vas deferens which has become spirally twisted.

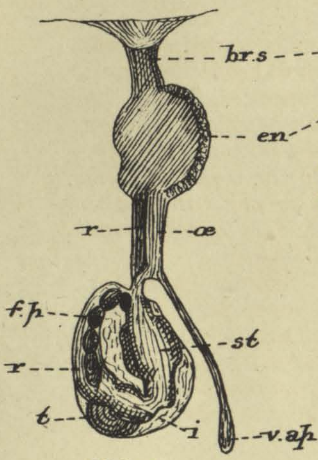
Or, perhaps better still, we may assume a common ancestor for the three genera, in which no spicules were present, and the reproductive organs were numerous, and arranged as in the Distomidæ. Gradually the power of forming calcareous bodies in the test was acquired as in *Cystodytes* among the Distomidæ, and the reproductive organs became variously specialised as we find them to-day.

Lastly, I would briefly enumerate a few points on which I think my researches shed new light.

The alimentary tract among the Leptoclinids is here more fully dealt with than by Herdman, and its variations are of undoubted specific import. Further, in *L. densum* a peculiar arrangement of the branchial pore is noted. The siphon is clearly six-lobed, but the pore itself three-lobed (*cf.* my figures and references with those of Herdman). A distinction must therefore be drawn between a plain branchial siphon (*i.e.*, one whose rim is plain) and a plain branchial pore. I have endeavoured in my descriptions to make this distinction, which is one of some value.

The question of the protogyny or protandry of the Ascidiæ Compositæ is an interesting one, about which opinions differ. Herdman contends for protogyny—the young zooids producing ova, and the older spermatozoa. But is this necessary to secure cross-fertilisation? The same result would evidently be attained if, each season, ova were produced first, and then spermatozoa when the ovaries were exhausted. In the absence of much definite information I can only speak with diffidence upon this point, but I certainly saw no ova in any young zooids, though sperm-bodies were frequently well developed, and in many cases ova were found among the viscera along with fully-developed spermatic vesicles.

The ova probably are fertilised either in the peribranchial cavity of the parent or in the cloacal canals. No oviducts were seen in any zooid, so that they must escape directly into the mantle-cavity of the thorax from the mantle-cavity of the abdomen, unless, indeed, they become fertilised in the abdomen, and pass out below through the mantle: in the Didemnids examined this seems possible, as no ova are found in



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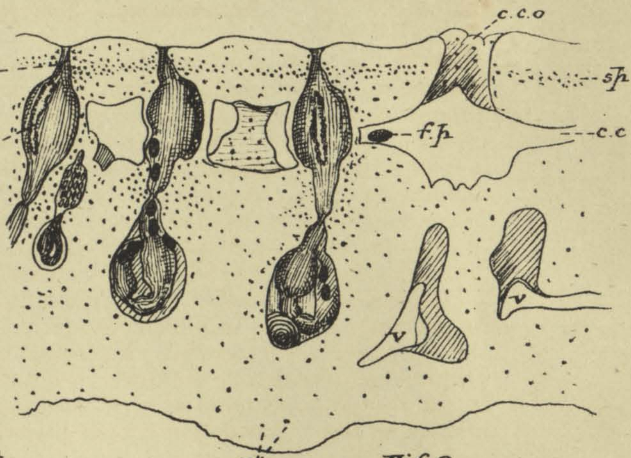

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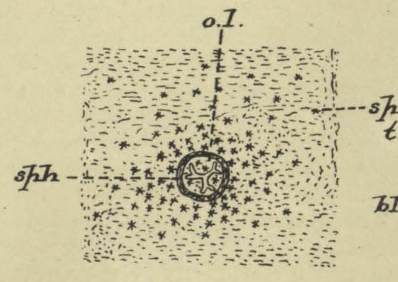

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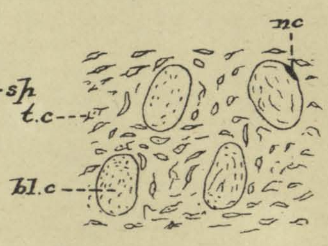

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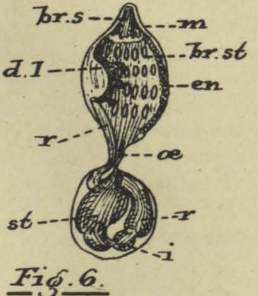

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Fig. 7.

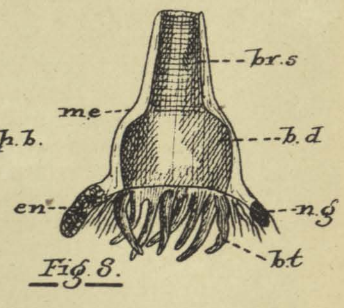


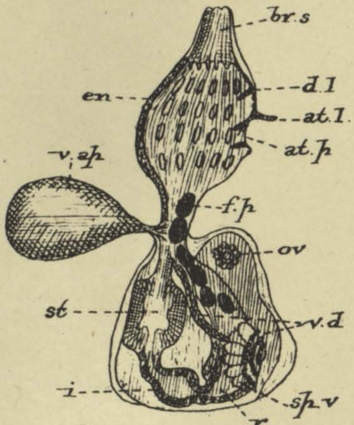
Fig. 8.

J. T. N. del.

N. Z. COMPOSITE ASCIDIANS.

Original Scale reduced 1/3.

C. H. P. lith.



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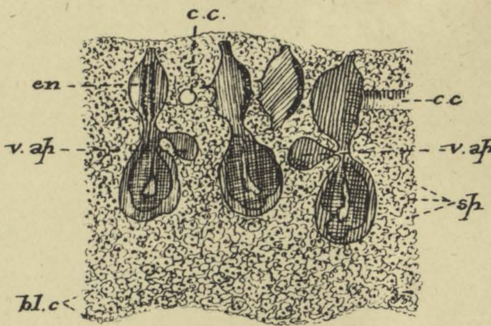

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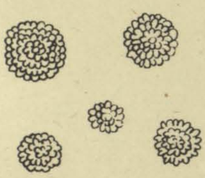

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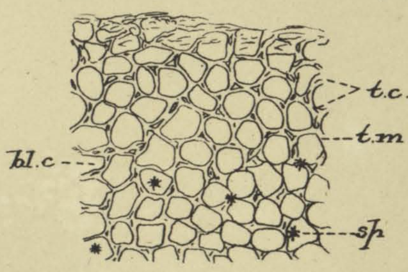

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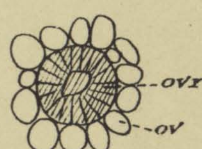

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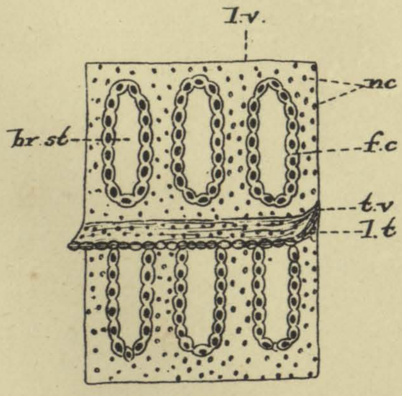

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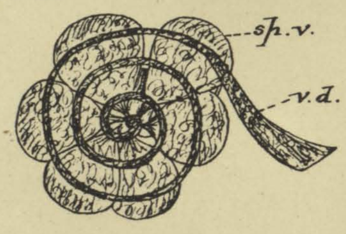
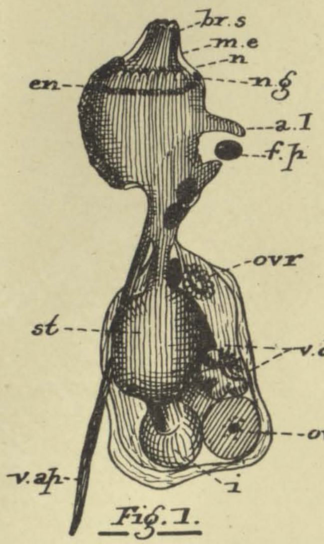


Fig. 7.

Fig. 8.

N.Z. COMPOSITE ASCIDIANS.

J.T.N. del. Original Scale reduced 1/3. C.H.P. lith.



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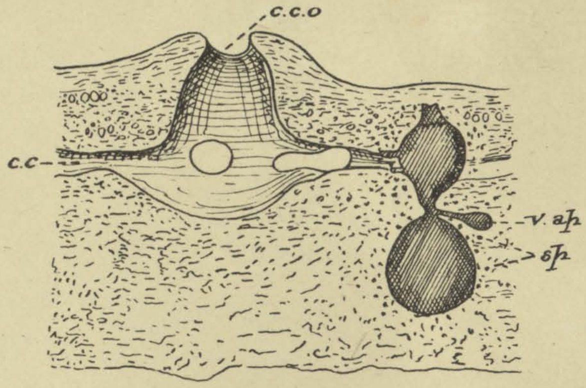

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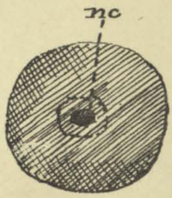

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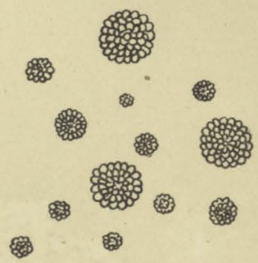

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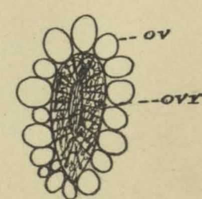

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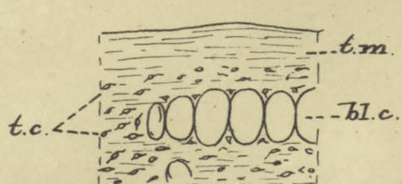

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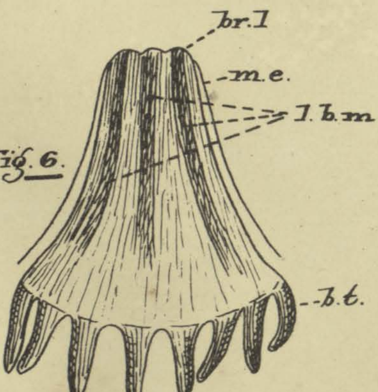

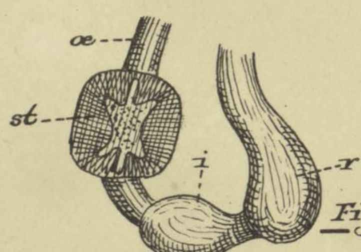

Fig. 8.

J.T.N. del.

N. Z. COMPOSITE ASCIDIANS.

Original Scale reduced 1/3.

C.H.P. lith.

N.Z. COMPOSITE ASCIDIANS.

Original Scale reduced 1/3.

J.T.N. del.

C.H.P. lith.

the upper test-layers. In any case, many ova probably escape through the cloacal cavities simply as fertilised ova if they pass into the peribranchial cavity prior to fertilisation. Those which thus escape may found new colonies. But many do not escape, burying themselves in the common test, where they undergo their development and metamorphosis.

Up to the present time only one species of New Zealand Composite Ascidian has to my knowledge been classified. This is *Botryllus racemosus*, from the mouth of the Thames River, catalogued by Hutton in his "Manual of the New Zealand Mollusca" (1879), along with two species of the genus *Pyrosoma*. These fragmentary observations of mine, deficient as they may possibly prove, are yet of interest in demonstrating the probable richness of our colonial waters in representatives of a section of the world's fauna so interesting as the Tunicata, and, though feeling conscious of much that is lacking in my account, I have no hesitation in offering it as the first fruits of what must ever be to me a deeply-absorbing life-work—the contributing somewhat to a fuller knowledge of Nature's marvellous handiwork.

KEY TO PLATES XXIV.–XXX.

a.p. Adhering papilla.
at.l. Atrial languet.
at.p. " pore.
at.s. " siphon.
b.d. Buccal dilatation.
b.t. " tentacle.
bl.c. Bladder-cell.
br.l. Lobe of branchial siphon.
br.p. Branchial pore.
br.s. " siphon.
br.st. " stigmata.
c.b. Calcareous bodies.
c.f. " fibres.
c.t. " trees.
c.c. Cloacal canal.
c.c.o. Common cloacal opening.
d.l. Dorsal languet.
en. Endostyle.
f.c. Fringing cell.
f.p. Fæcal pellet.
i. Intestine.
l. Larva.
l.b.m. Longitud. buccal muscles.
l.m. Longitudinal muscle.
l.t. Lamina transversalis.
l.v. Longitudinal vessel.
m. Mantle.
m.e. Mantle ectoderm (lining test).
n. Nerve ganglion.
nc. Nucleus.
n.g. Neural gland.
œ. Œsophagus.
œ.c. Œsophageal constriction.
o.l. Oral lobe (branchial lobe of Herdman).
ov. Ovum.
ovr. Ovary.
p.b. Pyloric bulb.
ph.t. Pharyngeal tubercle in test.
pp.b. Peripharyngeal band.
r. Rectum.
s.o. Sense-organ.
sp. Spicule.
sph. Branchial sphincter.
sp.m. Spicule membrane.
sp.v. Spermatic vesicle.
st. Stomach.
t. Testis.
t.c. Test-cell.
t.l. Test limit.
t.m. Test-matrix.
t.v. Transverse vessel.
tr.m. Transverse muscle.
v. Vacuole in test.
v.ap. Vascular appendage (test-vessel or ectodermal prolongation of mantle).
v.d. Vas deferens.

EXPLANATION OF PLATES XXIV.–XXX.

Plate XXIV.

Leptoclinum niveum.

Fig. 1. Part of a section of colony, showing the arrangement of spicules, &c. Enlarged about 26 diameters.
Fig. 2. Part of a section decalcified in hydrochloric acid, showing cloacal canals communicating with large ventral cavity. Enlarged 26 diameters.
Fig. 4. Buccal tentacles seen from beneath in cross-section. Zeiss obj. C, camera.
Fig. 5. Branchial aperture from above. Z. C, camera.
Fig. 6. Test-cells from decalcified section. Z. E, camera.
Fig. 7. Curvature of alimentary canal, seen in cross-section from above. Z. A, camera. Slightly enlarged.
Fig. 8. Group of calcareous spicules. Z. E, camera.
Fig. 9. Detail of branchial sac and dorsal languets. Z. E, camera.
Fig. 10. Zooid, showing arrangement of parts and method of gemmation, with reproductive bodies. Z. A, camera.

Plate XXV.

Leptoclinum densum.

Fig. 1. Portion of a decalcified section, showing common cloacal opening. Enlarged 26 diameters.
Fig. 2. Portion of a section in the natural state, showing the distribution of spicules. Enlarged 26 diameters.
Fig. 3. Test decalcified and strongly magnified, showing details of structure. Zeiss E, camera.
Fig. 4. Branchial aperture from above. Z. C, camera.
Fig. 5. Branchial siphon, with buccal tentacles. Z. C, camera.
Fig. 6. Spicules from test. Z. E, camera.
Fig. 7. Zooid, with testis and ovum and vascular appendage (test-vessel) *in situ*. Z. A, camera.
Fig. 8. Reproductive bodies. Z. C, camera.
Fig. 9. Portion of test (decalcified), with ovum and developing embryo. Z. A, camera.
Fig. 10. Tailed larva (abnormal), with 4 adhering papillæ. Z. A, camera.
Fig. 11. Normal larva (3 papillæ). Z. A, camera.

Plate XXVI.

Leptoclinum tuberatum.

Fig. 1. Part section of colony showing arrangement of spicules and passages in the test. Enlarged 26 diameters.
Fig. 2. Part section of colony decalcified, showing vascular appendages, &c. Enlarged 26 diameters.
Fig. 3. Surface layer of test, showing branchial apertures, position of zooids, spicules, &c. Zeiss A, camera.
Fig. 4. Group of spicules. Z. E, camera.
Fig. 5. Side view of branchial siphon, showing descending lobes of the test, tentacles, etc. Z. C, camera.
Fig. 6. Detail illustrating branchial sac and dorsal languets. Z. E, camera.
Fig. 7. Complete view of a single zooid showing the arrangement of parts and method of gemmation. Z. A, camera.
Fig. 8. Tailed larva, with sense-organs and adhering papillæ. Z. A, camera.

PLATE XXVII.

Leptoclinum maculatum.

Fig. 1. Complete view of single zooid, illustrating the peculiar elongated form of body and arrangement of internal organs. Zeiss A, camera.

Fig. 2. Portion of a section of the test, showing unusual form of cloacal canals, spicules, and vacuoles. Enlarged about 26 diameters.

Fig. 3. Spicules in a group. Z. E, camera.

Fig. 4. Branchial aperture showing arrangement of spicules around it. Z. C, camera.

Fig. 5. Detail of test highly magnified, with bladder-cells, &c. Z. E, camera.

Fig. 6. Young zooid with branchial stigmata, dorsal languets, &c. Z. A, camera.

Fig. 7. Transverse section through pharynx, viewed from below. Z. C, camera.

Fig. 8. View of branchial siphon from the side, with tentacles, nervous system, &c. Illustrating the peculiar dilatation (buccal mass). Z. C, camera.

PLATE XXVIII.

Polysyncraton paradoxum.

Fig. 1. Complete view of zooid, showing supposed vascular appendage, with internal organs *in situ*. Zeiss A, camera.

Fig. 2. Small portion of section, showing close arrangement of zooids, with cloacal canals, &c. Enlarged about 20 diameters.

Fig. 3. Group of spicules. Z. E, camera.

Fig. 4. Detail of structure in upper layer of the test, showing numerous bladder-cells. Z. C, camera.

Fig. 5. View of supposed ovary. Z. C, camera.

Fig. 6. Detail of branchial basket, showing the transverse lamina. Z. E, camera.

Fig. 7. Enlarged view of testis, showing numerous vesicles and spiral vas deferens with distal enlargement. Altered from a side view to scale of Z. C, camera.

Fig. 8. Transverse section through pharynx, viewed from beneath, with tentacles, nerve system, and endostyle. Z. C, camera.

PLATE XXIX.

Polysyncraton fuscum.

Fig. 1. Complete view of zooid with long filamentous vascular appendage, showing reproductive bodies, &c., *in situ*. Zeiss A, camera.

Fig. 2. Portion of section showing position of zooid with short bulbous vascular appendage, also large cloacal opening and canals. Enlarged about 20 diameters.

Fig. 3. Large ovum. Z. C, camera.

Fig. 4. Group of calcareous spicules, showing extreme variability in size. Z. E, camera.

Fig. 5. Supposed ovary. Z. C, camera.

Fig. 6. Branchial siphon in side view, with tentacles, and longitudinal buccal muscles running up to the buccal lobes. Z. C, camera.

Fig. 7. Detail of upper test-layer, showing the transparent matrix above, and test-cells and bladder-cells below. Z. E, camera.

Fig. 8. Separate view of alimentary canal: the stomach cut through longitudinally. Slightly enlarged from an outline taken with Z. A, camera.

Plate XXX.

Cystodytes aucklandicus and *C. perspicuus.*

Fig. 1. Portion of test showing spicules, calcareous trees (*c.t.*), fibres (*c.f.*), and calcareous bodies (*c.b.*). Enlarged 7 diameters.
Fig. 2. Zooid of *C. aucklandicus.* Zeiss *a**, enlarged.
Fig. 3. Detail of test in *C. perspicuus.* Z. C, camera.
Fig. 4. Calcareous spicule (tree) of *C. aucklandicus.* Z. A, camera.
Fig. 5. Calcareous crystals of *C. perspicuus.* Z. A, camera.
Fig. 6. Detail of form seen in fig. 4 under high magnifying power (Z. E). Drawn without reference to scale.
Fig. 7. Detail showing calcareous bodies forming radiating branches. Seen in unstained sections.
Fig. 8. Crystalline branching calcareous bodies from the region of the capsule. Z. A, much enlarged. Glycerine.
Fig. 9. Spicules from *C. perspicuus.* Z. A, camera.
Fig. 10. Surface-vessel in the test from *Cystodytes aucklandicus.* Z. C, camera.
Fig. 11. Branchial siphon with part of branchial basket of *C. perspicuus.* The upper part of the basket has been removed in sectioning, leaving the lower surface visible from inside. Z. C, camera.

Art. XXVI.—*On the Structure of* Boltenia pachydermatina.

By James Watt, M.A.

From the Biological Laboratory of the University of Otago.

[*Read before the Otago Institute, 11th August, 1891.*]

Plates XXXI.–XXXIV.

This species of *Boltenia* is found attached to rocks, piles, shells, &c., or lying loose on the sea-bottom. In the latter case, as a general rule, the specimens have become detached by the breaking of the stalk some distance from the base. Very often they are seen in bunches in masses of seaweed, in which cases, however, they are not directly attached to the seaweed itself, but have become united to it by the entangling among the seaweed of the shell or other base of attachment to which they have united themselves. The members of this species are often seen growing in bunches, when either a number have attached themselves to a shell or some such small base of attachment, the stalks becoming fused at their bases, or a number of younger specimens have fixed themselves to the stalk of a larger.

Anatomy.

A. *External Characters.*

a.—The body is somewhat ovate in shape, compressed laterally, slightly concave on the dorsal border, convex on the ventral. The posterior end is bluntly pointed, the anterior is narrow, becoming gradually continuous with the stalk. The