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Part I. Serpulidae

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47. Polychæta from the Pacific Coast of North America.—
Part I. SERPULIDÆ, with a Revised Table of Classification of the Genus *Spirorbis*. By HELEN L. M. PIXELL, B.Sc., F.Z.S., Demonstrator of Zoology and Reid Fellow, Bedford College, University of London.

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(Plates LXXXVII.—LXXXIX.)*

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General Characteristics of the Family Serpulidæ.

1. Tube calcareous, nearly always attached to rocks or other substratum for some part of its length.
2. Generally one or more branchiæ on dorsal side terminated by an operculum.
3. Thorax, generally provided with a thoracic membrane, representing the fused cirri and having 3–9 (usually 7) segments.
4. Gland shields in thorax only.

Genus SERPULA Linné (12) 1767, Philippi (21) 1844.

Generic characteristics † :—

1. Collar setæ of bayonet-shape, with spines at base of blade.
2. Operculum funnel-shaped, with numerous radii ending in serrations on margin.
3. Uncini with only a few large teeth.

1. SERPULA COLUMBIANA Johnson (9), 1901. (Pl. LXXXVII. fig. 1.)

Serpula splendens Bush (3), 1905.

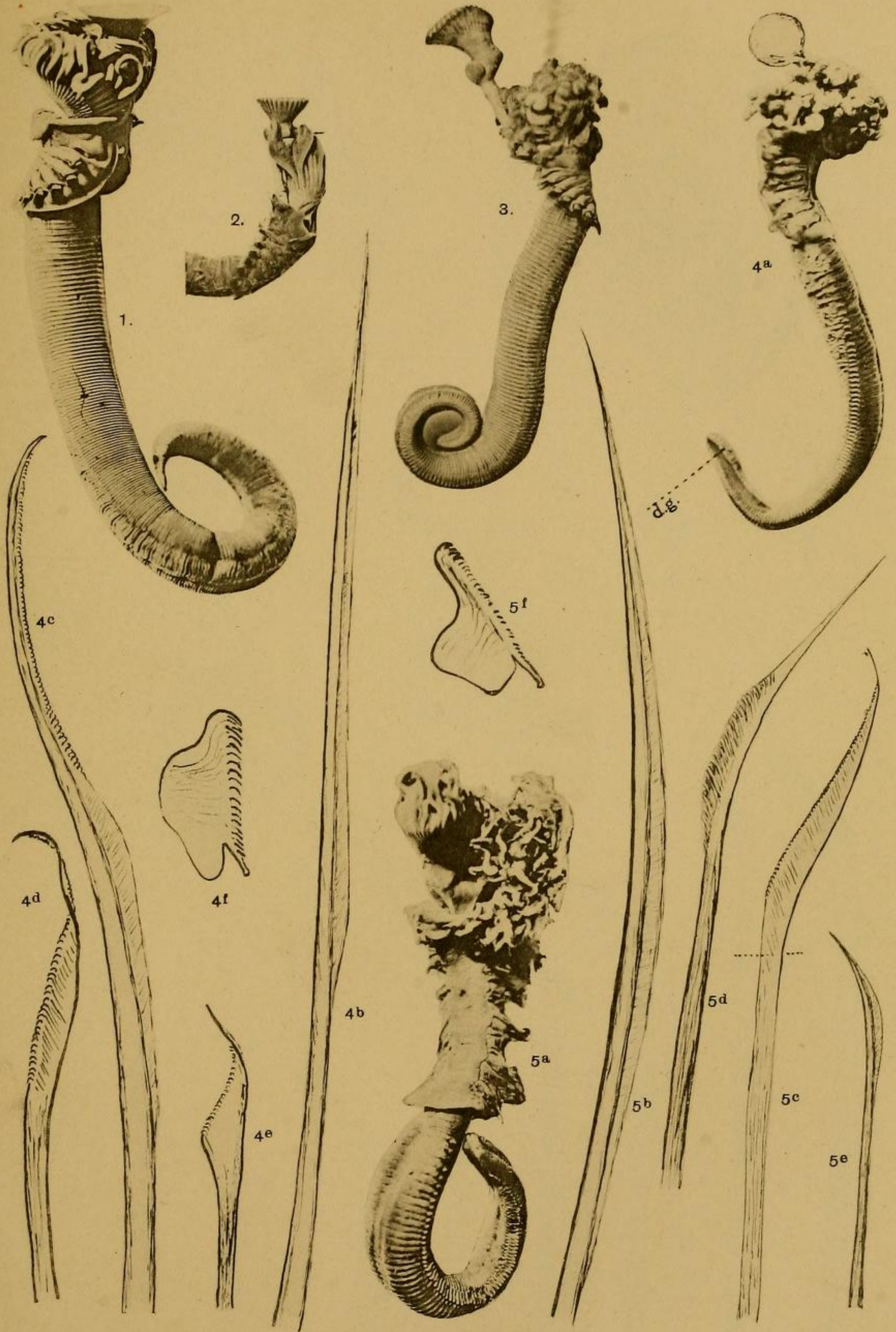
Serpula columbiana Moore (19), 1909.

Specific characteristics :—

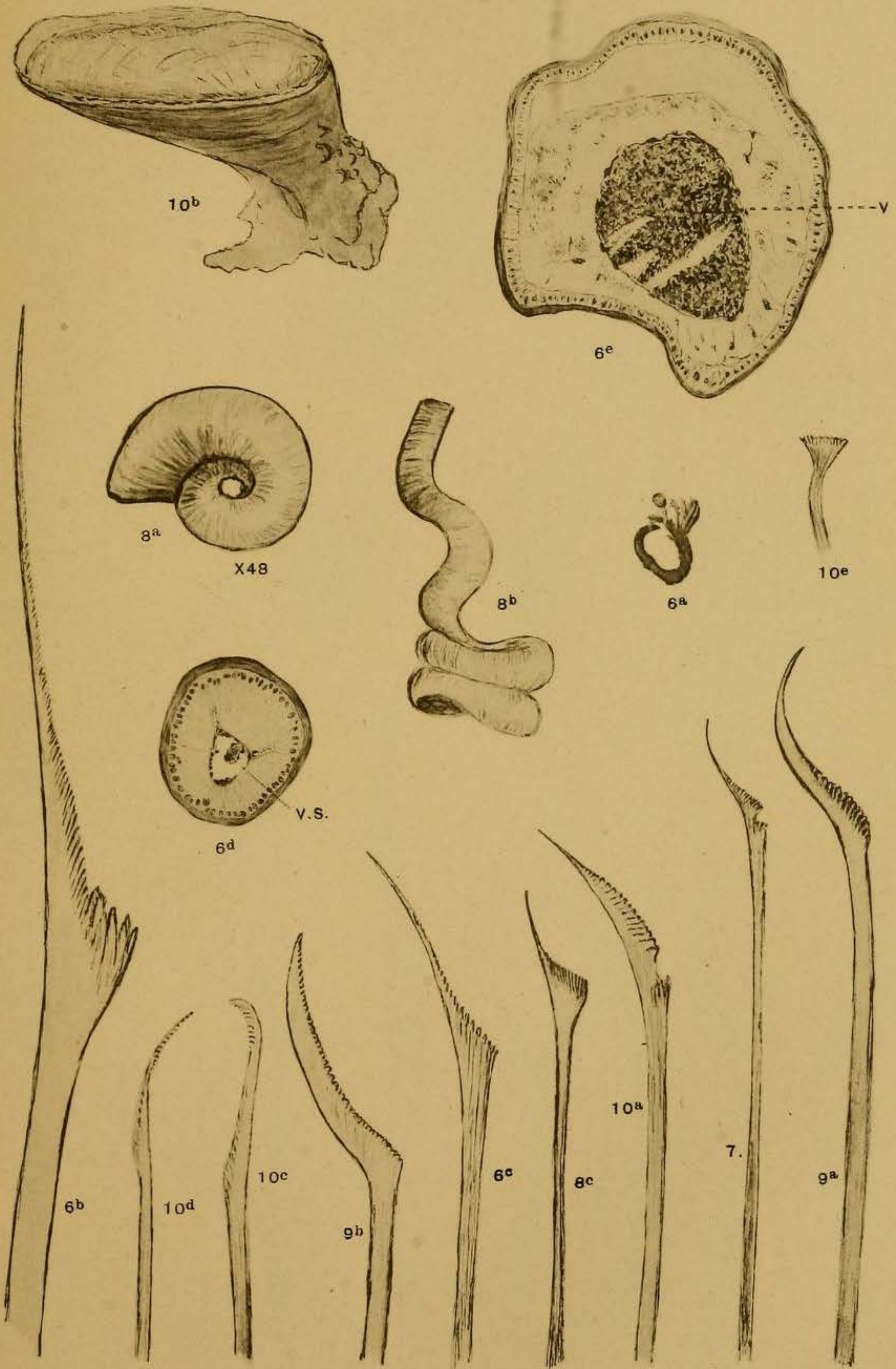
1. Anterior abdominal setæ with flaring fringed ends, short and deeply embedded, posteriorly replaced by small fascicles of very long stiff spines.

* For explanation of the Plates see p. 805.

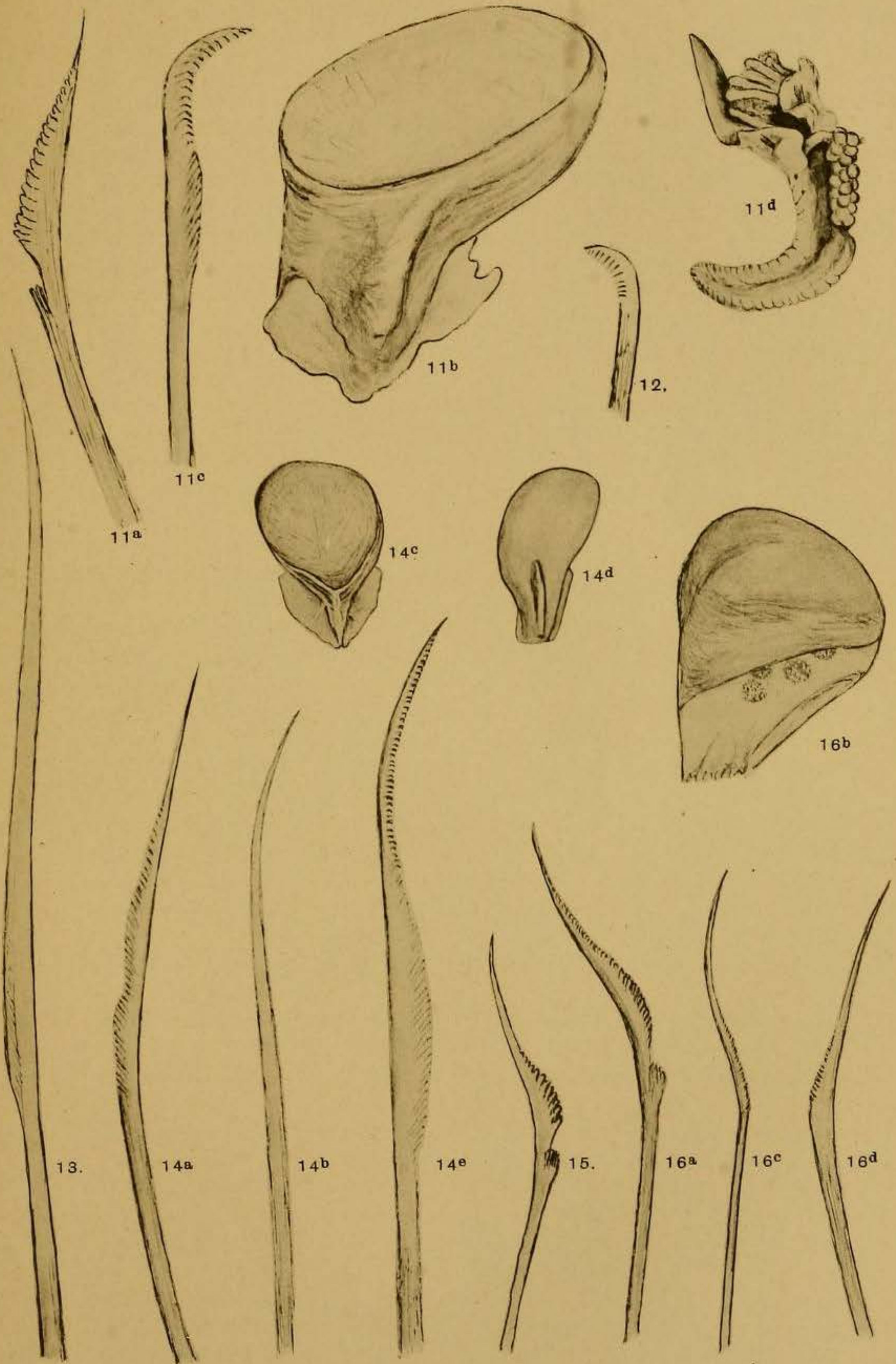
† An attempt is here made to summarise briefly the generic and specific characteristics in every case. Such a procedure has not previously been adopted, so far as I know, and it will, no doubt, in some cases be necessary at some future time to modify such characteristics, but in the present confused state of our systematic knowledge of the Serpulids, this seems to be a course likely to eliminate some of the difficulties.



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NORTH AMERICAN SERPULIDÆ.

2. Uncini generally 6 or 7 teeth, the anterior one being the largest (figs. 202 & 203 Johnson, 9).
3. Very large size (fig. 1) with numerous abdominal segments, 30 to 54 branchiæ and from 80 to 160 serrations on edge of operculum.

Numerous specimens from Departure Bay, Dodds Narrows, and two from Puget Sound (Prof. Kincaid's collection).

Isolated tubes are to be found attached to the undersides of stones on rocky shores near extreme low-water mark, and small colonies may be found above this level in rock-pools.

In other places attached to rocks near low-water level the masses of large white calcareous tubes are very striking—they are thick and often finely ridged, the lower parts being much intertwined, the free distal ends often overgrown with Polyzoa, *Spirorbis*, etc.

The brilliant red colour on the branchial crown may involve the whole of the gills and operculum, or these may be colourless except for the tips, or they may be barred and mottled in a large variety of ways. The remainder of the body is generally yellowish.

As regards collar, thoracic membrane, and operculum with its tubercles, this species agrees very closely with *S. vermicularis*, so fully described by St.-Joseph (24. pp. 328–335). Johnson (9) presumably has made it into a new species on account of its very much greater size with corresponding greater number of abdominal segments, branchiæ and serrations on operculum, together with small differences in the setæ and uncini. He cannot, I think, have examined many specimens, for he states that the functional operculum is on the right side (9. p. 432). The position of this in the genus *Serpula* may be right or left as shown by Zeleny (27. p. 34), but out of 50 specimens that I have examined 28 had it on the left, 21 on the right, and the remaining specimen had one on each side. Consequently, when he says that there are *about* 100 serrations on the edge of the operculum, I cannot think that Bush (3) is justified in recording this as a distinction between this species and *S. splendens* with 127 to 150 serrations.

Moore (19) gives 140 for the one specimen of *S. columbiana* in which he counted the serrations. In my specimens they vary from about 80 to 160—the number apparently increasing with age.

Another distinction given by Bush is that there are in *S. columbiana* "but 250 abdominal segments in a length of 55 mm.," whereas Johnson says "250 or more" (9. p. 432), and she gives 313 as the number in a specimen of her so-called *S. splendens*, of which she does not state the size, and 190 in a specimen 35 mm. long. These figures speak for themselves I think as creating nothing but confusion. In 15 of my specimens the average number of abdominal segments was 236, including 79 in a specimen 10 mm. long, 142 in a specimen 41 mm. long, and 310 in one 81 mm. long.

The third point of difference given by Bush is that *S. columbiana* has more numerous branchiæ—54 in each lobe as given by Johnson—than her *S. splendens*, for which she records 45 to 50 pairs.

In the specimen of the former species counted by Moore (19) there were only 38. One small specimen of mine had only 18, but the general number was from 30 to 50 on each side, one or two large specimens having as many as 54—the number given by Johnson. These facts show clearly I think that *S. splendens* is a quite unnecessary species and can be included in *S. columbiana*, which in turn, as pointed out by Johnson (9. p. 433), may be identical with *S. jukesii* Baird, for which however no satisfactory description was given.

Numerous large free Selenidia in the trophozoite stage were found in the alimentary canal of nearly every specimen of *S. columbiana* examined.

Genus CRUCIGERA Benedict (1), 1886.

Generic characteristics :—

1. Collar setæ and uncini similar to those of *Serpula*.
2. Operculum with comparatively few radii forming a scalloped margin to the funnel and with conspicuous basal processes.

2. CRUCIGERA ZYGOPHORA Johnson. (Pl. LXXXVII. fig. 2.)

Serpula zygophora Johnson (9), 1901.

Crucigera zygophora Bush (3), 1905.

Specific characteristics :—

1. Branchiæ about 30 pairs with long filamentous ends to rachises.
2. Operculum thick, shallow, with about 30 radii and 3 rounded processes at its base; attached by a long pedicle.

One specimen from Puget Sound was 45 mm. long. A smaller incomplete specimen came from Victoria (fig. 2). Another specimen was only 7 mm. long and had a much thinner operculum, but seemed otherwise similar.

3. CRUCIGERA IRREGULARIS Bush (3), 1905. (Pl. LXXXVII. fig. 3.)

Specific characteristics :—

1. Branchiæ much coiled and with comparatively short filamentous ends to rachises.
2. Operculum irregular, apex of funnel displaced ventrally and the posterior and lateral walls deeper and rolled over to some extent. Not more than two basal processes which may, however, be bi-lobed and attached by long stout pedicle (fig. 3).

About 12 specimens from the Channel outside Departure Bay

and one from Dodds Narrows. Depth 15 to 25 fathoms. Tubes generally solitary, attached to stones, shells, old wood, etc. Only one specimen is recorded by Bush from Juneau. Tubes much coiled, with flaring ends and one or two other conspicuous ridges at intervals indicating the flaring end of a younger tube. Young tubes seem to develop with a centimetre or so attached more or less straight along the substratum, then to coil indifferently to right or left, and only at a much later stage, if at all, to ascend and form the flaring end.

General colour pale orange, the branchiæ and operculum variously mottled and barred with red. Pinnæ sometimes golden; ova greenish. Length varies from about 14 mm. to 50 mm. (fig. 3).

Largest diameter of operculum 1.3 to 4.5 mm.; the latter had 32 radii forming a thick scalloped edge. The pedicle was bifid and contracted at the top just before joining the basal processes of the operculum (fig. 3). Setæ as figured by Bush (3); in the posterior region of the abdomen the ordinary setæ are replaced by small fascicles of long slender spines.

Genus *APOMATUS* Philippi (21), 1844.

Generic characteristics:—

1. Operculum globular, terminating a gill retaining its pinnæ.
2. Some thoracic setæ bladed sickles (setæ of *Apomatus*) (fig. 4 c).
3. Terminal dorsal gland present.

4. *APOMATUS TIMSII*, sp. n. (Pl. LXXXVII. figs. 4 a-4 f.)

Specific characteristics:—

1. Collar setæ simple tapered blades (fig. 4 b).
2. Branchiæ about 40 pairs with pinnæ nearly to the ends of rachises.
3. Uncinigerous tori begin on third setigerous segment.
4. Uncini with numerous small teeth, the posterior one larger with terminal enlargement (fig. 4 f).
5. Abdominal setæ more or less sickle-shaped with some long filiform ones in the last segments.

Eleven specimens from the Channel outside Departure Bay in about 20 fathoms. This is the first time apparently that the genus has been recorded from the Pacific Coast of America.

The tubes are solitary, adherent, and sinuous—one was attached along its whole length to a portion of the Hexactinellid sponge *Aphrocallistes whiteavesianus*.

When full-grown about 80 mm. with 150 abdominal segments (fig. 4 a).

The branchial rachises are much coiled and almost colourless, with pairs of red spots up their outer surfaces and only short filiform extremities—the pinnæ appear green due to the contained blood. The thorax is more or less orange or red, the thickened

ridges bearing the tori being especially deep in colour. Abdomen pinkish; there is a short anterior asetigerous region, and posteriorly nearly covering the last centimetre or so of dorsal surface is a chalky white strap-shaped raised glandular area. This is the terminal dorsal gland mentioned by St.-Joseph (24) as possibly serving in the construction of the tube. It tapers anteriorly and ends abruptly posteriorly just above the vertical slit-like anus.* Along nearly the whole of this glandular region the ordinary abdominal setæ are replaced by fascicles of about five slender capillary setæ without blades and nearly equal in length to the width of the abdomen at this place. The collar is entire ventrally and has a deep incision on each side—the lateral lobes being continuous with the wide thoracic membrane.

The functional operculum is large and transparent and carried by the second branchia from the dorsal side. The pedicle is generally coiled twice like the other gills; except in very young specimens there is a small club-shaped one terminating the branchia on the opposite side.

All the collar setæ and most of the other thoracic setæ have simple narrow blades; amongst them in the posterior thoracic fascicles are to be found a few of the typical bladed sickles (fig. 4 *c*). The abdominal setæ are more or less sickle-shaped, though they easily become folded (figs. 4 *d*, *e*) or straightened out.

Several of the specimens examined were much smaller and obviously young forms, with 70, 83, 101, 114 abdominal segments and fewer branchiæ than in adult specimens.

Genus PROTULA Risso (23), 1826.

Generic characteristics :—

1. No operculum.
 2. Collar setæ simple tapered blades (fig. 5 *b*).
 3. Terminal dorsal gland present.
5. PROTULA PACIFICA, sp. n. (Pl. LXXXVII. figs. 5 *a*–5 *f*.)

Specific characteristics :—

1. Ventral lobe of collar notched.
2. Abdominal setæ somewhat sickle-shaped in the anterior region, narrow terminal bladed ones posteriorly.
3. Uncinigerous tori extend from segment 3 to the end of the abdomen.
4. Uncini with numerous small teeth, the posterior one long with a bulbous extremity (fig. 5 *f*).
5. Thoracic setæ simple blades with sometimes a few setæ of *Apomatus* posteriorly.

* In section the gland is seen to consist of epithelial cells crowded with spherical granules which stain easily with iron hæmatoxylin but not with Delafield's. The gland is apparently unchanged by the presence of acid in the preservatives and therefore does not appear to be calcareous.

Three specimens from Fairway Channel outside Departure Bay in about 30 fathoms; one from Puget Sound (Prof. Kincaid's collection). No tube.

The specimens were colourless except for the branchiæ, which appear greenish due to the contained blood. Down the outer side of each branchial rachis was a line of opaque white spots.

The branchial crown (10–15 mm. high) easily falls off, leaving a scar; the remainder of the body is 38 to 60 mm. long, rather more than one-third of which is thorax. This is broad and flattened with nearly parallel sides (fig. 5*a*) and the usual 7 setigerous segments. The thoracic membrane is very wide, with an entire margin which can extend beyond the setæ but is generally considerably crumpled. The collar is notched in the median ventral line and has a deep fissure on each side. The inward coil of the stout base of the branchial crown is seen on the right side of the specimen in fig. 5*a*. It takes $1\frac{1}{2}$ to 2 turns inwards and upwards, the short inner gills reaching about the same height as the outer long ones. An interbranchial membrane connects the lower third of the gills, of which there are about 60 pairs having small closely placed pinnæ almost to their extremities. At the junction of the branchiæ with the stout basal membrane which carries them there is a slight ridge visible externally, and at this place on the inner side arises the oral membrane, which is continuous across the median line and up each of the spirals. On the dorsal side of the mouth is another shorter membranous lip.

Uncini begin on the third setigerous segment. They have the characteristic shape (fig. 5*f*). The first two millimetres or so of the abdomen is achætous, nearly round, and of smaller diameter than the wide dorso-ventrally depressed part which follows. The ventral surface has deep segmental grooves showing 83–110 segments, and a wide fæcal groove which turns to the right on reaching the thorax. Laterally the short tori are raised on distinct parapodial processes which extend to the posterior end of the body. The last 30 or so segments on the dorsal surface are covered with the calcareous-looking gland which anteriorly tapers off to two points, suggesting a paired origin.

In section the gland is seen to occupy nearly the whole thickness of the dorsal body-wall, the longitudinal muscles being pushed towards the sides. Nearly all the cells are crowded with the spherical granules or globules which stain easily with iron hæmatoxylin, and are apparently similar to those in the glandular cells so frequently found in the epidermis.

This hind region of the abdomen has very long setæ which extend 2 mm. or more on each side but are easily broken. At first sight they appear to be simple spines very slightly bent at the extremities, but, with high magnification, a narrow striated wing may be made out (fig. 5*e*), shorter setæ found with these are more distinctly winged (fig. 5*d*). The other abdominal segments have ventral fascicles containing about 13 short, stout,

somewhat sickle-shaped setæ (fig. 5c). These setæ were, unfortunately, not examined before being preserved, and as St.-Joseph (24. p. 338) points out, a lengthened immersion in alcohol tends to reduce the curve of the sickle.

In general structure this species resembles *P. capensis* McIntosh (13) fairly closely, but differs in the shape of the setæ and uncini: in the latter respect and in some other points it differs, too, from *P. diomedææ* Benedict (1). There are many characteristics distinguishing it from *P. superba* Moore (19) and other Pacific species that have been described. *P. atypha* Bush (3) might possibly be a young specimen of this same species.

Genus CHITINOPOMA Levinsen (10), 1883.

Generic characteristics:—

1. No thoracic membrane.
2. Collar setæ with fin-like expansion at base of blade.
3. Some of the other thoracic setæ are sickle-shaped.
4. Abdominal setæ geniculate.
5. Uncini with 9 or 10 fine teeth, the anterior one being larger and blunter than the others.
6. Operculum with horny plate.

6. CHITINOPOMA GREENLANDICA. (Pl. LXXXVIII. figs. 6a–6e.)

Serpula triqueter Fabricius (7), 1780.

Hydroides norvegica var. *grönlandica* Mörch (20), 1863.

Hydroides (?) *grönlandica* Malmgren (14), 1867.

Chitinopoma fabricii Levinsen (10), 1883.

Specific characteristics:—

1. Bodies elongated, somewhat cylindrical.
2. About 6 pairs of branchiæ with ends free from pinnæ.
3. Operculum enclosing central stalked vesicle.

Numerous specimens from Departure Bay and neighbourhood, one incomplete one from Victoria. In thick sinuous tubes adherent to shells, stones, etc., and having a very conspicuous dorsal keel generally ending in a spine overhanging the aperture. One tube was U-shaped with the two ends close together. The largest specimen was about 12 mm. long (fig. 6a). The whole animal was practically colourless, the pedicle of the operculum and the branchiæ sometimes having faint transverse bands, and the contents of the alimentary canal were in some specimens dark red.

The branchiæ varied very much in number (from 6 to 8 in each lobe) and some were frequently found in a rudimentary state: one specimen had 7 in the right, and only 3 fully-developed functional ones in the left. The operculum was in every case on the left dorsal side, and I have found no trace of a secondary one on the other side.

The full-grown branchiæ had about 17 pairs of ciliated pinnæ, which stopped short some distance from the top of the rachis leaving a fairly long filamentary end. In sections the rachises are seen to be strengthened externally by a thick layer of chitin, which also forms a protecting layer round the pedicle (fig. 6 *d*), and is continuous over the operculum with the thick horny plate on its top. This plate was often covered with sand, and many specimens had infusorians, etc. attached to it. The central cœlomic space in the pedicle is lined with peritoneum provided with very large conspicuous nuclei. There is a small vessel running along its whole length and enlarging in the opercular cup into a spherical vesicle (fig. 6 *e*). This is filled with a finely granular precipitate, and from its wall and general appearance seems to correspond with the branchial blood-vessels of the ordinary gill rachises, though I do not see that it can have any respiratory function. It is apparently suspended in a fine reticulate connective-tissue which easily shrinks away from the epithelial cells; Levinsen, in his original description (10. p. 203), suggested that it might be a new operculum forming in the old one.

The collar is very wide—the entire ventral lobe being generally reflexed—the latero-dorsal lobes are continued down the dorsal side to between the second and third thoracic setæ, where they end abruptly, giving the appearance of a short thoracic membrane. This was a constant characteristic in both small and large specimens. I have not seen it referred to before, but do not think it necessary on that account to separate this as another species.

With the large collar setæ (fig. 6 *b*) are a few shorter curved forms with very narrow blades.

The abdominal setæ agree with those described by St.-Joseph (24) for the genus (fig. 6 *c*).

The abdomen is long and slightly dorso-ventrally flattened, with 25–40 segments. The tori contain about 17 uncini, but there are only a few setæ to each segment. The dorsal longitudinal muscles are greatly developed—there is a small fascicle of ventral ones on each side of the wide fæcal groove. The large ventral nerve-cords are separated from one another. The epithelium consists of low columnar cells with numerous gland-cells containing the usual spherical masses which stain easily with iron hæmatoxylin.

This species seems to agree very closely with that described by Bush (3) as *Hyalopomatopsis occidentalis*. I cannot understand why this form with *no* thoracic membrane and “trumpet-shaped” abdominal setæ is put in a genus, of which St.-Joseph writes (24. p. 264): “Il m’a fallu créer un genre nouveau *Hyalopomatopsis* pour le *Hyalopomatus langerhansi* Ehl. et le *H. marenzelleri* Lang., qui par la présence d’une membrane thoracique . . . ne pouvaient rentrer, comme l’avait du reste prévu Langerhans, dans le genre *Hyalopomatus* tel que l’avait

défini von Marenzeller." St.-Joseph also gives as another characteristic of his genus *Hyalopomatopsis*, the presence of capillary setæ in all the abdominal segments.

Genus SPIRORBIS Daudin (6), 1800.

(Pls. LXXXVIII., LXXXIX. figs. 7-16.)

Generic characteristics and Schemes of classification :—

1. Calcareous tubes coiled in a dextral or sinistral spiral. The method of coiling and the markings on the tube have been used by Bush (3) in drawing up Table I., but the coiling of the tubes is variable (*cf.* figs. 8 *a* and *b*), being determined to a great extent by the nature of the substratum, and as Caullery & Mesnil (5) have already pointed out there is no constancy in either coiling or markings.
2. Branchiæ are constant in different species, the operculum with terminal calcareous plate, always occurring as the second on the concave side (*i. e.* the right in dextral forms and left in sinistral; since the animal lies with its back towards the substratum).
3. Thoracic segments generally 3—the first having only dorsal setæ—the two following have on each side an uncinigerous torus as well. In the subgenera given the prefix *Para-* by Caullery & Mesnil an extra torus (and in *Sp. cancellatus* a fascicle of dorsal setæ also) is developed on the concave side of the animal; this condition has been described in the following Table of Classification (p. 794) as $3\frac{1}{2}$ setigerous segments.

In *Sp. ambilateralis*, sp. n., there are four complete setigerous segments, although the fourth on the convex side is very reduced. This specimen therefore approaches the hypothetical *Prospirorbis*, described by Caullery & Mesnil (5. p. 233), who point out that the genus *Spirorbis* has been evolved from other Serpulidæ, which have the characteristic greater number of thoracic segments, by a gradual reduction. I have therefore placed this species in a new sub-genus *Protolæospira*.

4. Abdominal segments 8-40.

Between the thorax and the abdomen is a more or less long asetigerous region—often crowded with ova. The spermatozoa develop in the posterior setigerous segments.

5. The thoracic setæ are distinctive and the differences are of use as specific characteristics. Table II. given by Bush (3. p. 261) is drawn up with regard to these and the direction of the coiling alone.

As a rule, the first thoracic segment has some slender capillary setæ forming the inferior part of the fascicle (fig. 14 *b*)—the

superior ones, referred to as *collar setæ*, are distinctive, they may have simple blades (fig. 13) or there may be a distinct fin-like expansion at the base of the blade (figs. 7, 10 *a*, 11 *a*). In the case of sinistral forms Caullery & Mesnil referred the former to their sub-genus *Romanchella*, putting only those with a distinct fin in the sub-genus *Læospira*. In the species *S. verruca* and *S. evolutus* Bush and *S. medius*, sp. n., however, the setæ are intermediate between these two types, having blades which are faintly notched (fig. 14 *a*), showing an indication of a superior blade and inferior fin. Consequently I propose to do away with Caullery & Mesnil's sub-genus *Romanchella* altogether—taking *Læospira* to include all sinistral forms with three setigerous segments: it thus comes into line with the other three sub-genera proposed by Caullery & Mesnil (*cf.* Table of Classification).

The second thoracic segment has only ordinary bladed setæ, differing very little from one species to another.

The third thoracic segment has some ordinary bladed setæ, but generally also some bladed sickles as found so generally in the genus *Apomatus* (fig. 14 *e*).

In many Pacific species there are present instead of the ordinary bladed sickles a peculiar shorter form which appears almost fringed at the extremity (fig. 10 *c*).

6. Abdominal ventral setæ generally geniculate.
7. *Uncini* similar in thorax and abdomen—plates with the free edge provided with fairly numerous fine teeth, the anterior one being larger than the others.

The following Table of Classification has been adapted from that given by Caullery & Mesnil in their excellent paper on *Spirorbis* (5) to include such of the Pacific forms as have so far been studied. These authors pointed out that such a modification would possibly be necessary.

Unfortunately the majority of the new species described by Bush (2, 3, 4) from California, Alaska, and Japan cannot be included owing to absence of information as to the number of thoracic segments. Two or three of the species are established on details as to the tubes alone.

Sub-genus PARADEXIOSPIRA Caullery & Mesnil (5), 1897
(modified).

Characteristics:—

1. Tube dextral.
2. Thorax with $3\frac{1}{2}$ setigerous segments.

7. SPIRORBIS VITREUS Fabr., 1780. (Pl. LXXXVIII. fig. 7.)

Serpula vitrea Fabricius (7), 1780.

Spirorbis vitreus Mörch (20), 1863; Malmgren (14), 1867;
Levinsen (10), 1883; Caullery & Mesnil (5) 1897;
Moore (17), 1902; Bush (3), 1905.

TABLE OF CLASSIFICATION OF THE GENUS *SPIRORBIS*.

		SUB-GENERA.			
TUBE DENTRAL.	Paradexiospira. 3½ thoracic segments.	Last thoracic segment with dorsal setæ. Collar setæ with fins		<i>S. cancellatus</i> Fabr.	
		Last thoracic segment without dorsal setæ	{ Collar setæ with fins ...	<i>S. vitreus</i> Fabr.	
			{ Collar setæ without fins.	<i>S. violaceus</i> Lev.	
		Incubation in Tube.	{ Collar setæ without fins. Abdomen 10-20 setigerous segments.....	<i>S. spirillum</i> L. (var. <i>S. armoricanus</i> St.-J.)	
	{ Collar setæ with fins			{ <i>S. marioni</i> C. & M. <i>S. semidentatus</i> Bush.	
	Incubation in Operculum.		{ Collar setæ without fin. No bladed sickles in 3rd setigerous segment	<i>S. pseudocorrugatus</i> Bush. (<i>corrugatus</i> C. & M.)	
				<i>S. rugatus</i> Bush.	
				<i>S. comptus</i> Bush.	
				<i>S. foraminosus</i> Bush.	
		{ Bladed sickles in 3rd setigerous segment.....	<i>S. bellulus</i> Bush.		
<i>S. formosus</i> Bush.					
		{ Hepatic pigment violet. .	<i>S. pagenstecheri</i> Qfg.		
		{ Hepatic pigment red ...	<i>S. pusilloides</i> Bush. (<i>pusilla</i> St.-J.)		

TUBE
SINISTRAL.

Protolæospira , nov. 4 thoracic segments.	Embryos incubated in a dorso-lateral brood-pouch			<i>S. ambilateralis</i> , sp. n.			
		Paralæospira . 3½ thoracic segments.	Collar setæ with fins.	Talon of operculum a prolongation of terminal funnel.	Large collar setæ with fins. { Operculum (5) <i>S. malardi</i> C. & M.		
					Small collar setæ with fins. Operculum (fig. 11) <i>S. racemosus</i> , sp. n.		
					Small collar setæ with fins. Operculum (5) <i>S. patagonicus</i> C. & M.		
				Talon of operculum small and thin.	Uncini very thick (4µ) <i>S. aggregatus</i> C. & M.		
					Uncini (2µ) <i>S. claparedei</i> C. & M.		
					Talon of operculum massive; terminal plate very thick <i>S. lebruni</i> C. & M.		
				Operculum without talon			<i>S. levinseni</i> C. & M.
					Tube (sub-genus <i>Romanchella</i> C. & M.)	Operculum (5) <i>S. perrieri</i> C. & M.	
						Operculum (3) <i>S. asperatus</i> Bush.	
		Collar setæ simple blades. Incubation in	Operculum (sub-genus <i>Leodora</i> St.-J.).....	Operculum (22) <i>S. lævis</i> Qfg.			
				Operculum (3) <i>S. validus</i> Verrill.			
				Operculum (2) <i>S. argutus</i> Bush.			
		Collar setæ blades with shallow posterior notch.	Incubation in Tube <i>S. medius</i> , sp. n.				
			Incubation in Operculum <i>S. verruca</i> Fabr.				
Læospira . 3 thoracic segments.	Incubation in Tube.	Talon of operculum without external projection.	Blades of collar setæ with fine serrations <i>S. spirorbis</i> L.				
			Blades of collar setæ with coarse { Operculum (5) . <i>S. mediterraneus</i> C. & M.				
			Blades of collar setæ with coarse { Operculum (3) . <i>S. variabilis</i> Bush.				
		Talon of operculum with external projection.	Operculum (5) <i>S. cornu-arietis</i> Phil.				
			Operculum (5) <i>S. beneti</i> Mar.				
			Blades of collar setæ finely serrated.	Operculum (5) <i>S. koehleri</i> C. & M.			
		Operculum (5) <i>S. bernardi</i> C. & M.					
		Operculum (3) <i>S. similis</i> Bush.					
		Incubation in Operculum	Operculum (3) <i>S. quadrangularis</i> St.				
Blades of collar setæ coarsely serrated.	Operculum (5) <i>S. langerhansi</i> C. & M.						
	Operculum (fig. 16) <i>S. mörchi</i> Lev.						
		Operculum (5) <i>S. militaris</i> Clpd.					

Specific characteristics:—

1. Last thoracic segment on the right has no dorsal setæ.
2. Collar setæ with fin-like expansions at base of deeply serrated blades.
3. Some setæ of third segment bladed sickles.
4. Embryos incubated in the tube.

This species was quite common on stones and rocks from the Departure Bay region and from Victoria.

The tubes vary a good deal but are always translucent, with the whorls piled on one another. The whole tube measures about 2.5 mm. in diameter and the aperture about 1 mm. across. There are various markings on the exterior. Sometimes a ridge along the median line ends in a sharp projection above the aperture—in the grooves on either side of this there may or may not be scalariform markings. Young specimens have shells as figured for this species by Levinsen (10. fig. 11), older ones were ridged more like *Sp. cancellatus* (10. fig. 18). The living animals were bright pink in colour. Gills 7, each with six pairs of long opposite pinnae, opercular plate a shallow funnel. About 20 abdominal segments.

Sub-genus DEXIOSPIRA (Caullery & Mesnil, 1897).

Characteristics:—

1. Tubes dextral.
2. Thorax with 3 setigerous segments.

8. SPIRORBIS SPIRILLUM Linné, 1767. (Pl. LXXXVIII. figs. 8a–8c.)

Serpula spirillum Linné (12), 1767; Fabricius (7), 1780.

Spirorbis spirillum Malmgren (14), 1867; Levinsen (10), 1883; Caullery & Mesnil (5), 1897; Moore (17), 1902; Bush (3), 1905.

Spirorbis lucidus Montagu (16), 1803; Mörch (20), 1863; Malmgren (14), 1867.

Circeis armoricana Saint-Joseph (24), 1894.

Spirorbis borealis Fewkes (8), 1885.

Specific characteristics:—

1. Collar setæ geniculate (fig. 8c).
2. Operculum without brood-pouch.
3. Concave plate of operculum has a slight projection (talon) on under side.

Two varieties of this species were fairly common in the Departure Bay region and at Victoria, growing on calcareous polyzoa, seaweeds, etc. The discoid form grows only on smooth surfaces, Laminarian thalli being often extensively covered with specimens. These were very flat, regularly coiled tubes—the spiral with $1\frac{1}{2}$ to 3 coils measuring .5 to 2 mm. in diameter (fig. 8a). The

ascending variety in some localities is much more common than the discoid one, and it grows to a much larger size (fig. 8 *b*), often attaining a height of 5 mm. It was generally found with its lower coils overgrown with an orange Bryozoan growing on *Chaetopterus* tubes.

The living animal had a reddish colour, with a colourless transparent operculum. A string of pink ova extended along the tube beyond the posterior end of the body in some specimens. There were 3 thoracic and from 12 to 20 abdominal segments.

The collar setæ attain a length of .27 mm., much larger than those figured by Caullery & Mesnil (5. fig. 4 *b*), they resemble more closely in shape those given for *S. armoricanus* (5. fig. 5 *b*).

The differences between these two species were pointed out by Caullery & Mesnil (5. p. 199) to be quite unimportant. All that they could summarise were that *Sp. armoricanus* (*Circeis armoricanus* St.-Joseph (24. p. 350)) was slightly larger, had more abdominal segments (16-20) and a reduced talon to the operculum. They record having seen intermediate forms themselves, and the above observations as to variation in size, the number of abdominal segments, and the collar setæ consequently confirm their opinion that *Sp. armoricanus* should be considered as a variety only of *Sp. spirillum*.

9. SPIRORBIS PUSILLOIDES Bush (3). (Pl. LXXXVIII. figs. 9 *a*,
9 *b*.)

S. pusillus Caullery & Mesnil (5), 1897.

Mera pusilla St.-Joseph (24), 1894.

Non *S. pusillus* Rathke (22 *a*), 1836.

Specific characteristics:—

1. Collar setæ of a more or less geniculate form (fig. 9 *a*).
2. Embryos incubated in operculum.
3. Setæ of 3rd thoracic segment sickle-shaped.
4. Hepatic pigment reddish brown.

On stones from Taylor's Bay, Gabriole Island. This animal agrees in all important points with the full description by St.-Joseph (24. p. 351) for *Mera pusilla*. The collar setæ are a little more distinctly angulated at the base of the blade (fig. 9 *a*), but they have not the typical geniculate form described by Caullery & Mesnil (5. p. 202). They are much shorter than the setæ of the second segment and are decidedly hooked. The extent to which the setæ are hooked has been pointed out by St.-Joseph to be reduced by preservation (24. p. 338), so that this does not seem to be a very important point.

The opercular brood-pouch is somewhat cylindrical and bounded proximally and distally by calcareous plates, the talon is reduced to a small quadrangular projection.

The abdomen has eight segments, with large, more or less sickle-shaped setæ (fig. 9 *b*) and an asetigerous anal segment.

Sub-genus *PROTOLÆOSPIRA*, nov.

1. Tube sinistral.
 2. Four complete setigerous segments to thorax.
10. *SPIRORBIS AMBILATERALIS*, sp. n. (Pl. LXXXVIII. figs. 10 *a*–10 *e*.)

Specific characteristics:—

1. Collar setæ very large, conspicuously serrated blades with fin-like expansion at base (fig. 10 *a*).
2. Operculum without brood-pouch.
3. Talon of operculum with large hook-like process (fig. 10 *b*).
4. Some setæ of 3rd segment have fringed ends (fig. 10 *c*).
5. Some setæ of 4th segment ordinary bladed sickles.
6. Abdominal setæ brush-like (fig. 10 *e*).
7. Dorso-lateral brood-pouch.

Several specimens on the inner sides of shells of *Balanus nubilus* from Dodds Narrows, 15–25 fathoms. Tubes forming translucent sinistral spirals measuring 3 to 4 mm. across. The surface is distinctly corrugated outside, highly polished inside; the aperture measures 1 mm. in diameter.

Branchiæ 12—6 on the right, and the operculum with 5 others on the left. The pinnæ extend upwards and reach the same height as the rachises. The opercular plate (fig. 10 *b*) is very like that of *S. cornu-arietis* Marion & Bobretzky (15). From close to the point of origin of the pedicle arises a wide tube which passes across the dorsal surface beneath the left lateral lobe of the collar, and enlarges into the thin-walled brood-sac which lies along the dorso-lateral surface on the right side. This structure has never, so far as I am aware, been described before: it is figured and more fully described for *S. racemosus*, in which species it was first seen.

Collar wide and entire; the collar setæ rather more than 1 mm. in length (fig. 10 *a*). Setæ of 2nd segment very numerous, all with simple blades; these appear again in the 3rd fascicle, and with them some shorter bladed setæ with their extremities more or less curved and fringed (fig. 10 *c*). The setæ of the 4th thoracic segment are few in number; on the convex side of one specimen there were three bladed sickles (fig. 10 *d*) and three with plain blades. The uncigerous tori on the 4th segment are also smaller than on the two preceding, especially on the right (convex) side. The thoracic uncini are about 90 μ long and have 20–25 teeth. Those on the abdomen are only 25 μ in length. About 50 of the latter make up each of the tori which are very distinct on the 18–20 abdominal segments: they begin quite close to the posterior end of the thorax—the anterior asetigerous region of the abdomen being very short.

The collar setæ in this form seem to have been specially

developed, for according to Caullery & Mesnil (5) the possession of blade and fin is not a primitive characteristic, and they are also very large; possibly they are specially developed in correlation with its habitat in rapids where the tide runs from 7-9 knots an hour. The presence of the specially developed brood-pouch might perhaps receive a similar explanation.

Sub-genus PARALÆOSPIRA.

1. Tubes sinistral.
2. Thorax with $3\frac{1}{2}$ setigerous segments.

11. SPIRORBIS RACEMOSUS, sp. n. (Pl. LXXXIX. fig. 11.)

Specific characteristics:—

1. Collar setæ with fin-like expansion at base of very coarsely serrated blade (fig. 11 *a*).
2. Operculum with massive talon having lateral wings and a hook on ventral surface (fig. 11 *b*).
3. Thin-walled dorsal or lateral brood-pouch attached to the thorax at the base of the operculum (fig. 11 *d*).
4. Some setæ of 3rd fascicle bladed sickles (fig. 11 *c*).

A few large specimens from San Juan Island on barnacle-shells overgrown with calcareous sponge; smaller ones from Channel outside Departure Bay. Depth in both places 15 to 25 fathoms.

The largest specimen measures 5 mm. across the spiral; the tube is corrugated and generally rather loosely coiled, leaving a central hole.

Branchiæ 13—6 functional ones on each side; rachises have short tapered extremities without pinnæ; operculum not unlike that of *S. ambilateralis*, but the talon rather more massive and its outer concavity almost hemispherical and filled with débris.

The collar setæ are very large (fig. 11 *a*); the 2nd fascicle consists of plain-bladed setæ, and the 3rd contain some fringed sickles as well. There is a distinct third uncinigerous torus on the left side (fig. 11 *d*); the uncini have the usual shape.

There are 21 well-marked abdominal segments, each with three or four brush-like setæ and a long asetigerous anal segment. The brood-pouch with its distinct wide stalk seems to be peculiar to this and the last described species of *Spirorbis*: it does not apparently replace a gill, for the calcareous operculum is developed as usual on the 2nd to the left. The sac has a very thin wall, the large ova causing marked protuberances on its surface, the whole somewhat resembling a bunch of grapes (fig. 11 *d*).

Sub-genus LÆOSPIRA.

1. Tube sinistral.
2. Thorax with 3 setigerous segments.

12. *SPIRORBIS ASPERATUS* Bush (3), 1905; Sitka. (Pl. LXXXIX. fig. 12.)

Specific characteristics:—

1. Collar setæ with simple blades.
2. Operculum without brood-pouch.
3. Calcareous plate of operculum thin, with large lateral wings on its talon.
4. Some setæ of 3rd fascicle short fringed sickles (fig. 12), others with long narrow blades.

On an old Serpulid tube inhabited by a hermit crab. One specimen only. The opaque sinistral tube shows conspicuous growth-lines, and the whorls are somewhat piled on one another.

There are 12 or 13 reddish gills nearly hidden by the high collar, above which the operculum projects for some distance. The alimentary canal was greenish and the ova along the dorsal surface salmon-pink. The abdomen consisted of about 20 segments.

13. *SPIRORBIS VALIDUS* Verrill (26), 1874. (Pl. LXXXIX. fig. 13.)

S. verruca Levinsen (10), 1883, figs. + Caullery & Mesnil (5), 1897; Moore (17), 1902.

S. validus Bush (3), 1905.

Specific characteristics:—

1. All thoracic setæ with long, finely serrated, narrow blades (fig. 13).
2. Operculum with brood-pouch.
3. Opercular plate (Bush (3), pl. xliv. figs. 11-14).
4. Branchiæ 13.

On old shells of *Balanus nubilus* from Dodds Narrows, 15 to 28 fathoms.

The tubes were smooth, sinistral, and opaque, measuring 3 mm. in diameter. The operculum was colourless and transparent, with a large sac-like brood-pouch which was, however, empty in specimens collected on September 1st. The gills and thorax were of a bright orange-red colour, the rachises being thick with a double row of small pinnæ extending inwards at right angles. Abdomen with 25 segments having a few setæ, some being somewhat geniculate, others small hooks (Bush, pl. xxxvii. figs. 5 & 6).

14. *SPIRORBIS MEDIUS*, sp. n. (Pl. LXXXIX. figs. 14 a-14 e.)

Specific characteristics:—

1. Some collar setæ with shallow posterior notch (fig. 14 a).
2. Operculum without brood-pouch.
3. Calcareous plate of operculum very large and of characteristic shape (figs. 14 c & d).
4. Some setæ of 3rd segment serrated bladed sickles (fig. 14 e).

From Channel just outside Departure Bay. Large flat tubes

thick and opaque, slightly roughened, but without definite growth-lines. A slight median ridge and sometimes one on either side; the aperture has, however, an entire margin and measures 2 mm. across.

The animal is of a uniform brick-red colour, and its total length is 4.5 mm; there are 14 branchiæ—7 being joined at their bases and situated on the right side; the other 6 functional ones are joined with the operculum on the left. Each rachis has a thin membranous projecting flap which wraps round the outside of the next, and thus gives rise to a series of imbricating semilunar membranes just inside the base of the collar. The total height of the gills is 1 mm. There is a very wide thoracic membrane on the right side which almost envelops the whole animal. The calcareous plate of the operculum is 1.5 mm. along its long axis; the outer side is concave and generally covered with sand; the talon projects obliquely inwards and has large wing-like expansions at the sides (figs. 14 *c* & *d*). The collar setæ (fig. 14 *a*) appear to be in an intermediate stage between plain bladed form and that with a distinct fin-like expansion at the base of the blade—in one specimen I could find none of these, only forms with the ordinary blades. In the 2nd segment there were numerous setæ of the normal kind, and the 3rd fascicle was made up of bladed sickles (fig. 14 *e*) and ordinary bladed setæ. The two tori in the thorax consisted of uncini of the ordinary shape with about 20 teeth. In the abdomen were counted 20 to 25 segments, and the setæ were of the ordinary geniculate type.

15. *SPIRORBIS LANGERHANSI* Caullery & Mesnil (5), 1897, and Bush (3), 1905, from Panama. (Pl. LXXXIX. fig. 15.)

Specific characteristics:—

1. Collar setæ with fin-like expansion at base of coarsely serrated blade (fig. 15).
2. Embryos incubated in operculum.
3. Operculum of characteristic shape (5. fig. 22).

On tubes of *Serpula columbiana* from Departure Bay. Tubes small, marked with lines and ridges.

The structure of the animals agrees with the description given by Caullery & Mesnil (5. p. 217). They are 1–2 mm. long, the abdomen being broad, with a long asetigerous region followed by 9 short setigerous segments.

16. *SPIRORBIS MÖRCHI* Levinsen (10), 1883 (Greenland); Caullery & Mesnil (5), 1897; Bush (3), 1905. (Pl. LXXXIX. figs. 16 *a*–16 *d*.)

Specific characteristics:—

1. Collar setæ about 12, with fin-like expansion at base of coarsely serrated blade (fig. 16 *a*).
2. Embryos incubated in operculum (fig. 16 *b*).
3. Branchiæ 8.

Numerous specimens on tubes of *Serpula columbiana* from Departure Bay. The opaque tubes are pressed together with their ends standing erect, their bases being overgrown with an encrusting sponge; the surfaces are free from regular markings, the apertures being circular and measuring about 1 mm. in diameter.

The animals vary in colour, some being almost colourless, but were generally some shade of red or brown.

The setæ of the 2nd and 3rd thoracic segments have long, very narrow, delicately serrated blades (fig. 16 *c*). A few of the 3rd are shorter, with small posterior blades; these probably represent straightened sickles (fig. 16 *d*).

There is a deep collar and a wide thoracic membrane on the right side only—this traverses the ventral surface obliquely towards the end of the thorax and covers over several segments of the abdomen. The gill rachises are thick and have long pinnæ, the seven normal respiratory ones are rather taller than the one bearing the operculum. The latter is protected at its extremity by a convex calcareous cap which extends nearly to the base of the brood-pouch on the ventral side. The top is quite opaque and slightly bilobed. Fifteen or more large reddish ova were contained. Abdominal segments 20–29 with normal geniculate setæ.

17. SPIRORBIS VARIABILIS Bush (3), 1905; Sitka.

Specific characteristics:—

1. Collar setæ coarsely serrated blades with posterior fins.
2. Operculum without brood-pouch.
3. Talon of operculum without projections.

On stones and tubes of *Serpula columbiana* from Departure Bay and neighbourhood. Thick tubes about 1 mm. across with the outer whorl spreading over the others to some extent; surface markings were not very distinct.

General colour brick-red, with cerise ova along the dorsal surface.

Branchiæ 8 (including operculum), are nearly hidden by the high collar. The thoracic membrane on the right side is very much developed. The opercular plate had a marked concavity on its outer side, and a small almost central talon projecting inwards. The setæ agree with those described by Bush (3). The abdominal segments varied a great deal in number, from 15 to 28.

18. SPIRORBIS QUADRANGULARIS Stimpson (25), 1853.

Spirorbis quadrangularis Mörch (20), 1863, and Bush (3), 1905.

Spirorbis fabricii Malmgren (14), 1867.

Spirorbis carinatus Levinsen (10), 1883 + (11), 1886 + Montagu (16), 1803.

Spirorbis affinis Levinsen (10), 1883.

Spirorbis granulatus Moore (17), 1902 + (?) Caullery & Mesnil (5), 1897.

Specific characteristics :—

1. Collar setæ finely striated blades with basal fin.
2. Operculum with large brood-pouch.
3. Convex calcareous cap with long cylindrical projection (figs. 14, 15, pl. xliii., Bush (3) 1905).

Victoria ; two specimens only obtained.

Tubes measure 2 and 3 mm. across respectively ; each has a very conspicuous median ridge and two lateral ones, the outer one being at the top of the perpendicular outer wall. The striations on the blades of the collar setæ could hardly be distinguished at all. Some setæ in the third fascicle were serrated, bladed sickles. The collar and thoracic membrane were well developed on the right side, and there was a long asetigerous region following the thorax. There were 12 abdominal segments with geniculate setæ.

Most of the specimens described in this paper were obtained during a stay at the Marine Biological Station, Departure Bay, Vancouver Island, in the summer of 1911. Mr. F. A. Potts kindly collected those from Puget Sound and some others: I should like to take this opportunity of thanking him, also the Rev. G. W. Taylor, F.R.S.C., Curator of the Marine Laboratory, Departure Bay, for his kindness and help with regard to dredging arrangements, and Dr. Marett Tims for his advice and assistance throughout.

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EXPLANATION OF THE PLATES.

PLATE LXXXVII.

- Fig. 1. *Serpula columbiana* from left side, $\times \frac{3}{2}$.
 Fig. 2. *Crucigera zygophora*, anterior end from right side, $\times 2$.
 Fig. 3. *Crucigera irregularis*, whole animal from right side, $\times 2$.
 Fig. 4. *Apomatus timsii*. 4*a*, whole animal from the right side, $\times 3$, *d.g.*, dorsal terminal gland; 4*b*, collar seta, $\times 300$; 4*c*, bladed sickle-shaped seta from thorax, $\times 300$; 4*d*, crumpled anterior abdominal seta, $\times 300$; 4*e*, short posterior abdominal seta $\times 300$; 4*f*, thoracic uncinus, $\times 300$.
 Fig. 5. *Protula pacifica*. 5*a*, ventral view, $\times \frac{3}{2}$; 5*b*, thoracic seta, $\times 300$; 5*c*, anterior abdominal seta, embedded up to the dotted line, $\times 200$; 5*d*, short posterior abdominal seta, $\times 300$; 5*e*, tip of long posterior abdominal seta, $\times 300$; 5*f*, abdominal uncinus, $\times 300$.

PLATE LXXXVIII.

- Fig. 6. *Chitinopoma greenlandica*. 6*a*, dorso-lateral view, $\times 2$; 6*b*, collar seta, $\times 460$; 6*c*, abdominal seta, $\times 460$; 6*d*, transverse section through pedicle of operculum, *v.s.* stem of vesicle, $\times 55$; 6*e*, transverse section through operculum showing vesicle (*v*) suspended in a loose connective tissue, $\times 48$.
 Fig. 7. *Spirorbis vitreus*, collar seta, $\times 220$.
 Fig. 8. *Spirorbis spirillum*. 8*a*, tube of discoid variety, $\times 48$; 8*b*, tube of ascending variety, $\times 10$; 8*c*, collar seta, $\times 200$.
 Fig. 9. *Spirorbis pusilloides*. 9*a*, collar seta, $\times 460$; 9*b*, large abdominal seta, $\times 460$.
 Fig. 10. *Spirorbis ambilateralis*. 10*a*, collar seta, $\times 220$; 10*b*, calcareous plate of operculum, lateral view, $\times 48$; 10*c*, seta from 3rd thoracic segment, showing fringed sickle-shaped extremity; 10*d*, ordinary bladed sickle, from 4th segment (twisted end); 10*e*, brush-like abdominal seta. *c-e*, $\times 220$.

PLATE LXXXIX.

- Fig. 11. *Spirorbis racemosus*, sp. n. 11*a*, collar seta, $\times 220$; 11*b*, calcareous plate of operculum, $\times 48$; 11*c*, seta from 3rd thoracic segment, $\times 460$; 11*d*, dorsal view of whole animal showing stalked brood-pouch, $\times 12$.
 Fig. 12. *Spirorbis asperatus*, seta from 3rd thoracic fascicle, $\times 460$.
 Fig. 13. *Spirorbis validus*, collar seta, $\times 460$.
 Fig. 14. *Spirorbis medius*, sp. n. 14*a*, collar seta showing shallow posterior notch, $\times 460$. 14*b*, ordinary capillary seta from 1st fascicle, $\times 460$. 14*c*, calcareous plate of operculum, dorsal view, showing talon and lateral wings, $\times 16$. 14*d*, latero-ventral view of opercular plate, showing flat talon with lateral wing-like projections, $\times 16$. 14*e*, serrated bladed sickle, $\times 460$.
 Fig. 15. *Spirorbis langerhansi*, collar seta, $\times 460$.
 Fig. 16. *Spirorbis mörchi*. 16*a*, collar seta, $\times 220$. 16*b*, operculum containing ova, lateral view, $\times 48$. 16*c*, narrow seta of 2nd and 3rd fascicles, $\times 220$. 16*d*, seta from 3rd fascicle, $\times 220$.