XIX. GOLFINGIA MACINTOSHII, *a new Sipunculid from the Coast of Scotland.*

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(Plates LV. & LVI.)

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WHEN I was staying at St. Andrews last summer (1884) my friend Professor MacIntosh, knowing my interest in the class to which it belonged, very kindly presented me with an exceedingly remarkable Gephyræan which he had obtained ten years previously from a friend who had dredged it in St. Andrews Bay, south of Montrose, at a depth of ten fathoms.

The specimen was obviously something new, and was noteworthy, not only on account of its external structural features, but on account of its large size.

The anticipations, based on its external appearance, were justified by a dissection of the specimen, which I carried out in the intervals of exercise with the club and ball sacred to the classic "green" of St. Andrews; and I have accordingly ventured to dedicate the new genus of Sipunculid worms indicated by this specimen to the local goddess whose cult is historically associated with the most ancient of Scottish seats of learning. "*Golfingia*" forms an appropriate parallel to the Scandinavian genus of Echiurid Gephyræans called "*Hamingia*" by Koren and Danielssen.

External Features.—Golfingia, as exhibited in the spirit-preserved specimen before dissection, presented the appearance drawn in Pl. LV. fig. 1. It measured five inches in length, and consisted of a soft-walled cylinder of white silky surface, marked with dark dots, as in *Sipunculus punctatus*. At either end of this soft-walled cylinder a hard dark brown-coloured spout or smaller cylinder is observed. One of these is the "posterior sclerite" or "scleropyge," the other is the "anterior sclerite" or "sclerorhynchus." In the living state the proboscis or "introvert" which *Golfingia* possesses, like all other Sipunculids, would issue from the sclerorhynchus in the way shown in fig. 2. Both scleropyge and sclerorhynchus are modifications of peculiar structures occurring in *Aspidosiphon*, and are found in the cylindrical form only in *Golfingia*. The scleropyge is the same organ as the posterior "shield" of *Aspidosiphon*, whilst the sclerorhynchus is represented by the anterior shield of *Aspidosiphon* and by the calcareous ring of *Clöeosiphon*.

The scleropyge is shown in figs. 3, 4, 5, so as to exhibit its surface-markings. Its walls are very thick and quite inflexible. It probably was moved as though hinged to the soft body, and was used in burrowing in sand. The body-cavity is continued into it, and the nerve-cord extends more than halfway along it, giving off numerous nerve-filaments (Pl. LVI. fig. 11). It is imperforate. The sclerorhynchus is similarly shown in figs. 6, 7, 8.

In the median dorsal line, at the base of the sclerorhynchus, is placed the triangular anal aperture (*a*). Symmetrically on each side are the external apertures of the paired nephridia (brown-tubes), fig. 6, *dl*, *dr*. The sclerorhynchus is as solid and thick-walled as the scleropyge. Its surface is marked by elongated quadrangular areæ differing from the rougher transverse rugæ of the scleropyge. The anterior extremity of the sclerorhynchus presents an opening (fig. 7). This is the orifice of invagination of the proboscis or introvert, which, when withdrawn, carries with it the tentacular crown and mouth. The form of these parts was made out by dissecting them in their introverted condition (see figs. 9, 10, 12).

The introvert is soft-walled, its outer surface being beset with numerous papillæ, and near the mouth with chitinized hooklets (as in many Sipunculids). These are shown from different regions of the introvert in figs. 17, 18, 19, 20, and 21. The introvert measured, when extended, two inches and a half in length (fig. 2 *d*). At its free extremity is placed the mouth *e*, surrounded by a circlet of six symmetrical tentacles. Each tentacle is pinnate, carrying two rows of small processes (about twenty-four in all). A single tentacle is shown in fig. 13 and part of one in fig. 14.

Internal Features.—The body-cavity (cœlom) is spacious, as in *Sipunculus*. The characters of the coagulated cœlomic fluid could not be ascertained.

The long-muscles of the body-wall form a smooth continuous coat, *i. e.* they are not divided into groups, as in *Sipunculus*, *Phymosoma*, and some species of *Aspidosiphon*.

The intestinal coils did not extend further than two thirds of the length of the body. This may have been due to the action of the spirit; but I am inclined to think not. Thus, the posterior third of the body and the scleropyge were simply filled with cœlomic fluid, and contained no "floating" viscera. The intestinal coils were held together and to the body-wall by a delicate mesentery, as in *Sipunculus*. The position of the retractor muscles of the introvert, and the relations of the brown tubes (nephridia), rectum, œsophagus, and nerve-cord to these and to one another are shown by the drawings of the dissections made (figs. 9, 10).

There are four retractor-muscles of the introvert, as in *Sipunculus* (not two only, as in *Aspidosiphon*). Two of these are attached anteriorly and dorsally (*h*), and two posteriorly and latero-ventrally (*i*).

The anterior pair arise on each side of the rectum, but not quite symmetrically. The posterior pair arise over (and are perforated at their bases by) the nerve-cord, which lies here on the animal's left side near the middle ventral line.

The anus of *Golfingia* lies at the base of the sclerorhynchus in the middle dorsal line, and the ventral line corresponding to this is the ventral median line. The nerve-cord does not occupy this middle ventral line, and the only internal structures which exhibit a strict bilateral symmetry in their position are the nephridia (see diagrams, figs. 15, 16, *g*). The nephridia lie right and left of the symmetrical sclerorhynchus, equally distant on either side from the anus. In the dissection they are seen as shrivelled brown sacs (figs. 9 & 11). I could not discover their internal openings. In the dissection (fig. 9) the four retractor-muscles are seen attached to the introvert at the point *t*, and the nerve-cord (*ff*)

is seen attached loosely to the whole length of introverted proboscis (*y*). From the middle point between the retractors passes backwards the œsophagus (*l*) lying in close proximity to the rectum; a little way back they are twisted round one another. A curious muscular band (the spindle-muscle of Selenka) accompanies the rectum (figs. 9, 10, *m*), and is attached, after running a length of two inches, to the wall of the intestine. A similar muscular band exists in *Sipunculus nudus* (and most Sipunculids), arising in that animal from the curious little cæcal pouch which exists on the rectum at the distance of an inch or so from the anus.

I could not find any trace in *Golfingia* of this cæcum, nor of the "bush-like organs" near the anus, which appear in *Sipunculus nudus*, possibly to represent in a rudimentary form the posterior nephridia (cloacal trees) of the Echiuridean Gephyræa.

Owing to the imperfect state of preservation of the specimen, I am unable to state whether any vascular system of one kind or another exists in *Golfingia*, nor am I able to give any indication as to the position of the gonads.

The distinctness of *Golfingia* from all other genera of Sipunculid Gephyræans will be obvious at once to those who have studied this group of animals. The species I dedicate to my friend Prof. MacIntosh, not only in recognition of his vast services to marine zoology, but in memory of a long-standing friendship marked by many acts of kindness on his part.

The relation of *Golfingia* to other genera of Sipunculidean Gephyræans will be best appreciated by the reader if I make use of the synoptic table recently published by Selenka, and assign *Golfingia* its place in a modification of that table. It is not far removed from *Aspidosiphon*, but differs from that genus both in the form of its sclerites and in the disposition of the retractor-muscles and the character of the oral tentacles.

Sipunculoidea.

(Slightly modified from "Die Sipunculiden" of Dr. E. Selenka, Wiesbaden, 1883.)

Marine worms with cylindrical elongate bodies, with obliterated segmentation; only in the larval stage sometimes lateral, serial pairs of bristle bundles are present. Larva with a well-marked prostomial area, and a ciliate band, *which is post-oral*. The mouth, lying at the fore-end of the body, is provided with tentacles into which the body-cavity never penetrates, but only the vascular system; in rare cases there are no tentacles. Skin with numerous glands; overlying the cerebral ganglion is often a pair of ciliated tubercles. The long, tubular, alimentary canal is almost in all cases spirally rolled; very seldom is it simply thrown into loops; the anus is dorsal in position and far forward. The front part of the body (introvert) is introversible by the action of retractor-muscles; anteriorly on the introvert are very generally present chitinous hooks. The cœlomic fluid contains corpuscles. The closed vascular system encloses a corpusculated fluid, and consists of one or two contractile sacs (hearts)—which accompany the œsophagus and end blindly after a short course—and of the vascular ring and tentacular vessels. The circulation of the blood is effected both by the contraction of the heart's walls and by the action of ciliated cells; in very exceptional cases there is no vascular

system. There are no special respiratory organs. A pair of nephridial sacs (rarely only one) are always present and always (?) have an internal aperture. The reproductive organs lie in the form of transverse ridges at the base of the ventrally attached pair of retractor-muscles (of the introvert); the eggs have numerous pore-canals in their chorion; sexes distinct. Free or living in shells or tubes. In all seas.

Key to the Genera of Sipunculoidea.

I. *The longitudinal musculature of the body-wall is continuous and not divided into separate bands. The retractors of the introvert vary in number from one to four.*

1. Phascolosoma.—Two nephridia. Numerous tentacles surrounding the mouth in a circlet. A complete intestinal coil, unattached posteriorly (only in *M. Hanseni* attached); a spindle muscle is usually present; only on the anterior intestinal convolutions are there one or more ligaments. Adhesive papillæ are always absent. Hooklets are generally not present on the introvert. The retractors are four, two or only one. Eggs spherical. In all seas.
2. Dendrostoma.—Two freely suspended nephridia. Only four to six pinnate tentacles. A complete, posteriorly unattached, intestinal coil; spindle-muscle always present; ligaments present only on the anterior intestinal coils. Hooklets are present, but may be shed early in life. Four or two retractors. The contractile sac (of the vascular system) generally has cæca upon it. Tropical forms.
3. Phascolion.—A single nephridium, only that of the right side, which is attached to the body-wall throughout its length. The intestine forms no spiral or only an incomplete one; there is no spindle-muscle, whilst the loose intestinal loops are attached throughout their length to the body-wall by numerous ligaments. Adhesive papillæ are often present. The retractors are not more than two. Eggs spherical. Living in Gastropod shells or in tubes. In all seas.

II. *The longitudinal musculature of the body-wall is divided into* 17–41 *separate bands. Four* retractores introversi.

4. Phymosoma.—Body covered with papillæ. Numerous filamentous tentacles, which seldom (or never?) surround the oral aperture, but are arranged away from the latter, dorsally in a three-quarter-circle which is open dorsal-wards. No cæcum on the rectum. Hooklets nearly always present on the introvert. Four retractors (in *P. Ruppellii* two?). Contractile sacs almost always devoid of villi. Eye-spots are always present. Eggs elliptic, flattened, reddish. Small tropical species.
5. Sipunculus.—Body without papillæ. Tentacles surrounding the mouth in a circlet. Always one or several cæca on the rectum (except in *S. edulis*?). Hooklets absent, only present in *S. australis*. Eggs spherical. The individual tentacles thick, with an internal vascular network (not three longitudinal vessels merely); generally two contractile sacs. Mostly large forms. In all seas.

III. *In front of the anus and also at the hinder end of the body a distinct shield (corneous thickening of the integument), or in front of the anus a calcareous ring or a tube-like cornification, forming the base of the introvert, and another at the tail-end. Hooklets sometimes present. Longitudinal muscles continuous or divided into bands.*

6. Aspidosiphon.*—An anal and a caudal shield. Introvert eccentric arising from beneath the anal shield ventrally. Tentacles small and not numerous, placed in a semicircle above the mouth.

* See Dr. C. Ph. Sluiter, "Beiträge zu der Kenntniss der Gephyreën aus dem Malayischen Archipel.," Natuurk. Tidsch. v. Nederlandsch-Indie, Deel xliii. (1884), pp. 26–88, with 4 plates.

Intestinal spire traversed by a spindle-muscle, which is fastened at the hinder end of the body. Only two retractors, ventral in position and often fused with one another.

7. Clöeosiphon.—Directly in front of the anus a calcareous ring, from the centre of which the introvert is extruded. Longitudinal musculature continuous. Hooklets bifid. Tropical.

8. Golfingia.—A præanal corneous tube (sclerorhynchus) and a caudal corneous tube (scleropyge). The introvert issues centrally from the præanal tube, which is, in fact, its basal portion indurated. Tentacles six, pinnate, surrounding the mouth in a circle. Retractors four, two ventral longer, and two dorsal shorter, the two pairs arising at some distance from one another on the body-wall. Chitinized hooklets are present at the oral extremity of the introvert; further back on the same are found cylindrical and subspherical chitinized papillæ. Longitudinal musculature continuous. Intestine not coiled throughout in a spire, not fastened posteriorly; a spindle-muscle present. Two freely suspended nephridia. Vascular system uncertain. Known species large (eight inches long when expanded).

IV. *Only two lamelliform tentacles. Four retractors. Few intestinal loops, quite free. No vascular system.*

9. Petalostoma.

V. *No tentacles. No vascular system. A single retractor. A single nephridium.*

10. Onchnesoma.—Introvert long. Body small, pear-shaped.

11. Tylosoma.—No introvert (?). Body cylindrical, thickly beset with papillæ, which are more closely set and larger at the front and hind ends of the body.

DESCRIPTION OF THE PLATES.

Letters apply to all figures.

a. Anus, in the median dorsal line.
b. The sclerorhynchus (anterior sclerite).
c. The scleropyge (posterior sclerite).
dl., *dr*. Right and left nephridial aperture.
e. Mouth.
f. Nerve-cord.
ff. Nerve-cord attached to the introvert.
g. Nephridia (brown tubes, oviducts or sperm-ducts.)
h. Anterior retractors of the introvert.
i. Posterior retractors of the introvert.
k. Rectum.
l. Œsophagus.
m. Muscular band accompanying the rectum.
n. Musculature of the body-wall (smooth).
o. Epidermis and cutis.
p. Muscular attachment of the nerve-cord within the scleropyge.
q. Six terminal filaments of the nerve-cord (cauda equina).
r. The peri-oral tentacles.
s. Papillary surface of the introvert.
t. Point of attachment of the retractor-muscles to the introvert.
u. Chitinized ridges on the cuticle of the introvert.
v. Hooks on the same.
w. Soft papillæ.
x. Chitinized papillæ.
y. The introvert.

Plate LV.

Fig. 1. The specimen of *Golfingia MacIntoshii* of natural size and appearance, after ten years' preservation in spirit.

2. Diagram of *Golfingia MacIntoshii*, with expanded introvert and tentacular crown: natural size.

3. Ventral view of the scleropyge.

4. Dorsal view of the scleropyge.

Fig. 5. Lateral view of the scleropyge.

6. Dorsal view of the sclerorhynchus and anterior part of the soft body. Showing anus *a* and position of nephridial aperture *dl, dr*.

7. View of the anterior aperture of the sclerorhynchus.

8. Ventral view of the sclerorhynchus.

9. Dissection of the specimen of *Golfingia MacIntoshii*, showing the position of the introvert *y* and its retractor-muscles *hh*, the nephridia *gg*, the nerve-cord *f*, and the rectum *k*, and œsophagus *l*. The body-wall has simply been cut along a line nearly corresponding to the median ventral, and reflected on either side.

10. The introvert and œsophagus have now been thrown forward, after cutting the latter and the retractor-muscles so as to show the position of the anus, and the attachment of the nephridia to the base of the sclerorhynchus internally.

Plate LVI.

Fig. 11. The scleropyge opened by a dorsal, median, longitudinal slit, so as to show the nerve-cord lying within its cavity.

12. The introvert opened by a longitudinal incision, so as to expose its papillary surface *s* (the true outer surface here seen as introverted); the tentacles *r* and the mouth *e*.

13. A single tentacle enlarged to show the pinnæ.

14. Apex of a tentacle.

15, 16. Diagrams of transverse sections taken near the base of the sclerorhynchus, to show the asymmetry of the arrangement of organs; fig. 15 includes the introvert; fig. 16 is just behind it.

17. A portion of the integument from near the oral extremity of the introvert, viewed from the outer surface and showing the mesh-like arrangement of chitinized ridges *u*, and numerous hooklets *v*, also the soft papillæ *w* placed in the spaces of the mesh-work. It is a question as to whether the soft papillæ are an early condition of the chitinized hooklets, or are entirely distinct structures. The position of the hooklets *on* the ridges, and of the papillæ *in the space* enclosed by the ridges, favours the latter supposition.

18. A small piece of the same, showing clearly the relation of the hooklets to the ridges.

19. A similar portion of integument taken a little further back (the hooklets do not extend for more than a quarter of an inch behind the oral aperture), showing the ridges *u*, more powerfully developed, and no hooklets.

20. A similar portion of integument a little further back than fig. 19 (about three quarters of an inch from the mouth), showing the chitinization of the papillæ *x*, and the reduction of the ridges, to pigmented tracts. The chitinized papillæ are apparently the same structures as the soft papillæ *w*, of figs. 17, 18, 19.

21. Lateral views of three chitinized papillæ from the same region.

Fig. 1.


Fig. 3.

Fig. 4.


Fig. 5.

Fig. 2.


Fig. 8.

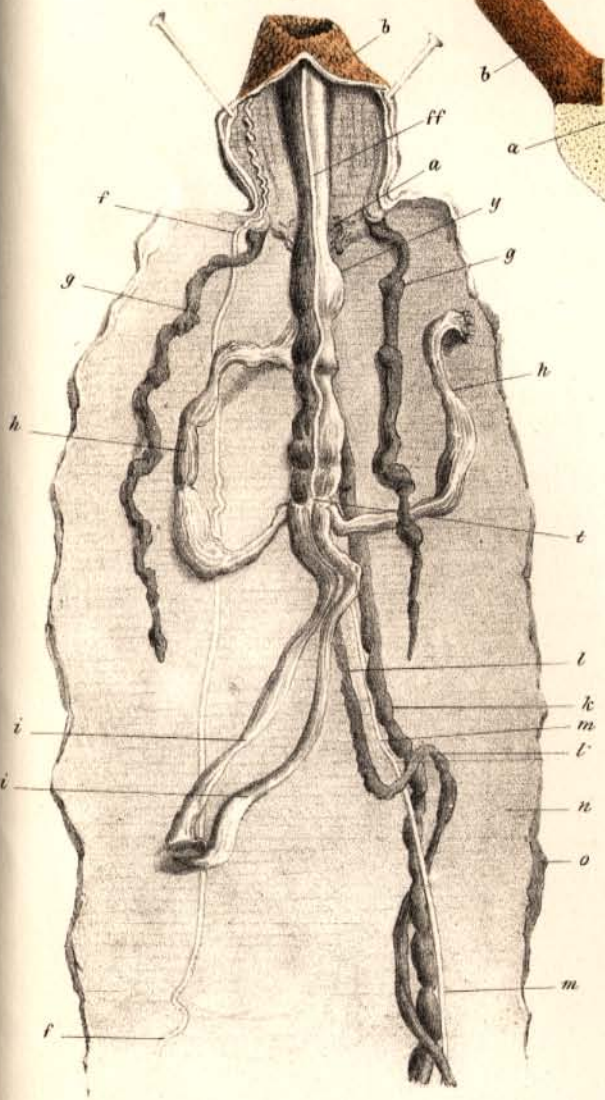

Fig. 9.


Fig. 7.

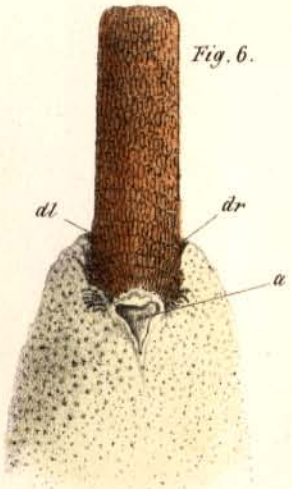

Fig. 6.

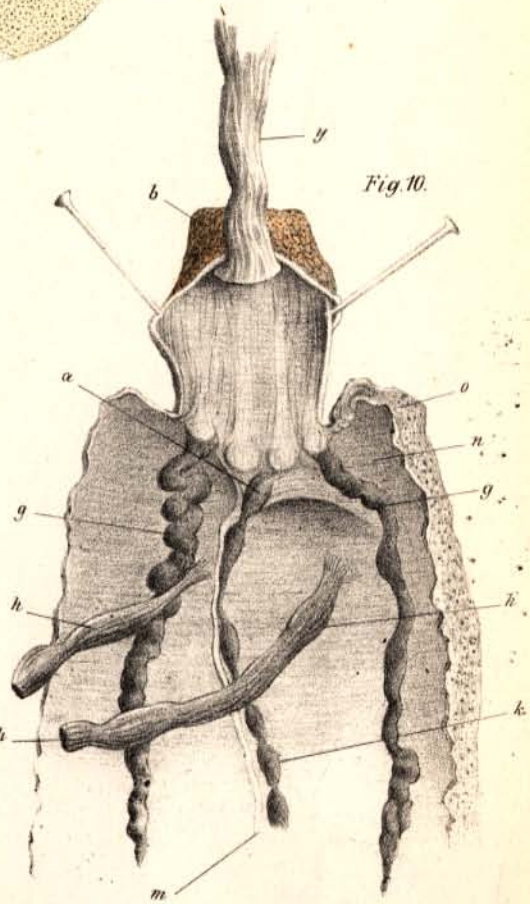

Fig. 10.

Hammond lith. GOLFINGIA Mc INTOSHII & ITS ANATOMY. Hanhart imp.

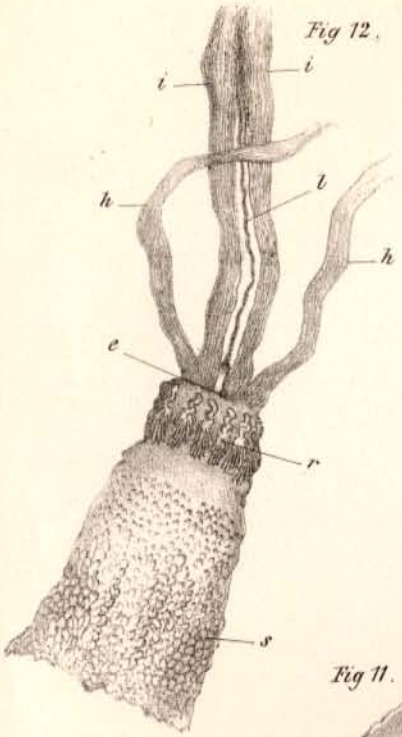

Fig 12.

Fig 13.

Fig 14.

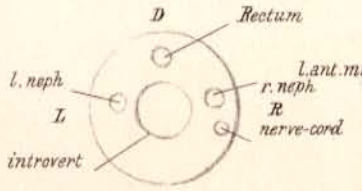

Fig 15.

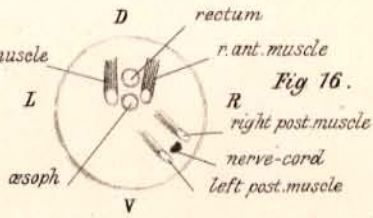

Fig 16.

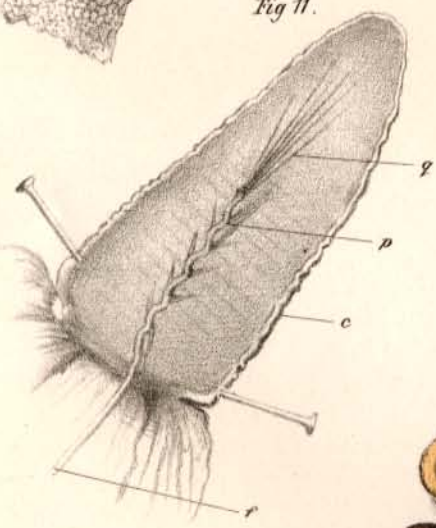

Fig 11.

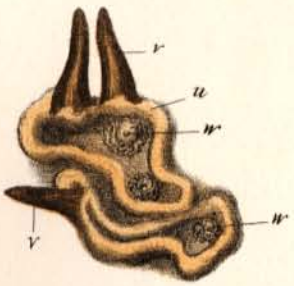

Fig 18.

Fig 17.

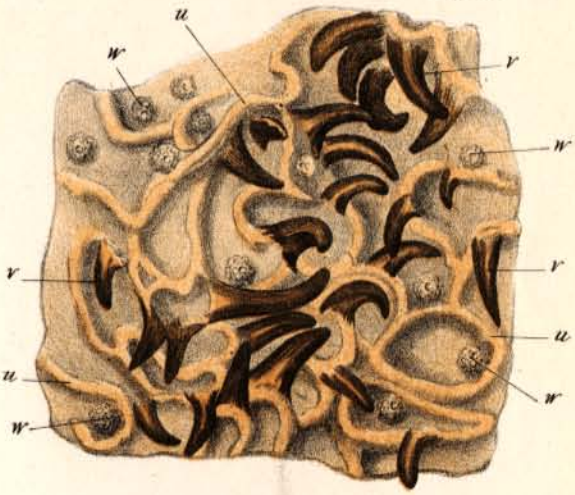

Fig 20.

Fig 19.

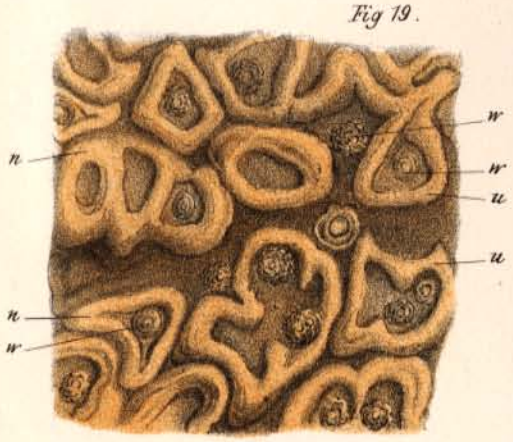

Fig 21.