Studies on Sponges.

By

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I. On Velinea gracilis n. g.; n. sp.

With Plates 31 and 32.

Two years ago I found in the Collection of the Zoological Station a curious species of Sponge, to which I alluded in my report to the Dutch Government[1].

The Sponge in question was dredged in the Bay of Naples, but I did not obtain any indication of the depth. It consists of a colony of cylindrical tubes, the whole being about 9 cm in height. The colour, in spirit, is a yellowish-brown. The slender, rather compact, tough, tubes, with their terminal oscula give to the Sponge the appearance of a siliceous Sponge, so that at first sight one would think to have to do with something allied to *Siphonochalina* (fig. 1).

In observing the Sponge with a lens we see over the whole surface little elevations, due to more or less protruding horn-fibres (fig. 2). These give the Sponge, for which I propose the name *Velinea gracilis*, the appearance of shagreen, if seen with the naked eye. Between the ends of the fibres are to be seen the pores, being, as is usual, the entrances of the canalsystem. These pores are not very frequent and vary considerably in diameter (fig. 3); the water, having passed through them, comes in the so called subdermal-cavities, these being a system of lacunae just under the dermis. I cannot say whether these cavities communicate all together, but I am sure that a number of the holes as they are visible in sections (*s.d.c.* in the figures) do communicate,

[1] G. C. J. Vosmaer, Voorl. berigt etc. in Ned. Staatscourant No. 109. 1881.

in order to form under the dermis a kind of large reservoir in which here and there columns of Sponge-substance connect the floor with the roof of the cavity. From these subdermal cavities goes off a system of canals or lacunae that penetrates the Sponge nearly reaching the inner wall of each cloacal tube. These very wide canals give off numerous ramifications in all directions; the secundary branches ramify again and so on, but each secondary branch has a smaller diameter than the primary ones. Besides these wide canals the subdermal cavities give off narrow ones (fig. 20 α, β); these seem not to ramify; they do not penetrate the Sponge to a great depth. In fig. 20 the difference between the wide and narrow canals is very conspicuous; the character as subdermal cavities with their narrow canals is very clearly shown in α and β; in γ on the contrary one can hardly speak of a subdermal cavity. A large series of sections teaches us the fact that both are only varieties of the same principle and not at all two different cases. In figs. 16, 17 and 18 I have chosen examples of such a series; in fig. 16 there are for instance, two subdermal cavities marked with + and 0; a few sections farther in one direction we see the cavity 0 enlarged, but in stead of the cavity + we see two very small ones, and the broad canal ++ deeper (fig. 18). A few sections in the other direction show us where both cavities + and 0 are in direct communication with the canal ++, that penetrates nearly the whole Sponge (fig. 17). These inhalant canals ramify during their course into the Sponge, the branches becoming always narrower (fig. 4). Much wider are the exhalant canals. Under the inner wall of each cloacal tube are immense lacunae, ramifying in different directions as they go to the peripheral part of the tube, and diminishing in their diameter (fig. 4). The inhalant canals begin thus as wide passages, ramify and become narrower, the exhalant on the contrary uniting with one another become thus wider and wider. The sections of the first show as a rule a diameter greater than, or at least equal to, those of the exhalant canals, in the outer parts of the Sponge-tube (fig. 4). The contrary takes place in the inner parts. Of course in the middle their diameter will be about equal. The two systems of canals communicate by means of the ciliated chambers. These are rather large and pouch-shaped, resembling those described and figured by F. E. Schulze of *Spongelia*[1]. They do not occur in every part of the Sponge, but form a special region. Outward this region is the system of subdermal cavities; inward another system of cavities, belonging to

[1] F. E. Schulze, Zeitschr. f. wiss. Zool. XXXII. Bd. (1878). p. 153.

the exhalant canals. The chambers that are found just under the subdermal cavities receive the water directly from these (fig. 4 *s.d.c.*); they communicate by pores. Those which lie more towards the centre receive the water by the inhalant canals (fig. 4 *i.c.*). Around the more or less cylindrical afferent or exhalant canals they are radially arranged and over the whole length; transverse and longitudinal section will make this clearly; both are to be seen in fig. 4. Although typically they are pouch-shaped and open with a wide mouth directly into the canals, there are modifications of this form that remind us of the system of other Sponges. In figs. 5—9 I have drawn different shapes of ciliated chambers. In fig. 6 and 8 there are some that resemble those of the *Spongidae*, showing even the beginning of a special afferent canal. It must however not be forgotten that these forms are exceptions and that in general they are pouch-shaped as in *Spongelia*. As regards the number of the pores this seems to be very variable. The maximum I saw on thick sections was 12, so that in all, one chamber may have more than 20 pores.

Although very often it may appear that exhalant canals also function as inhalant, this seems to be an error. Numerous complete series of sections showed me that the inhalant canals in the innermost parts of the body never communicate with exhalant ones, but always came from other inhalant ones. So I believe that the water, once having passed a ciliated chamber, does not enter another, but is carried away.

Thus we have in *Velinea* as usual two systems of ramifying canals lying rather close together and in communication by ciliated chambers.

Each branch of the Sponge-colony is a more or less cylindrical tube, the canal in the middle of which we may call the cloacal cavity. In this cloacal cavity all the excurrent canals open. The diameter of the cavity is not everywhere the same; and there is present an arrangement for altering the size of the lumen. In observing a tube from the top, very often a thin membrane with a circular hole is visible; it is highly probable that this membrane works as a sphincter. The cloacal cavity is partly filled up here and there by a spongeous mass, as is to be seen in figs. 19 and 21. In this whitish soft substance are no skeleton-fibres; the whole mass consists only of connective tissue.

Velinea has a very remarkable skeleton. It consists of a rather regular network of horny fibres, which lie in the three dimensions of space. On transverse sections it is to be seen that one system of fibres passes in a radial direction, while another is a system of concentric fibres. At the place, where they unite, the longitudinal fibres come

together also (fig. 22). Let us call for a moment these latter ones primary fibres, those coming off from them secondary ones. The primary fibres go for the greater part in a longitudinal direction; but afterwards they bent out toward the periphery; the result is that the outer, thinner, younger parts go in a nearly radial direction. During their course they send off secondary branches, which connect the primary branches. Thus on transverse sections a network of fibres is seen, the radial ones of which consist mainly of the secondary fibres, but partly of the bent-out extremities of the primary ones. Those fibres that go in a concentric direction consist on the contrary only of secondary branches. Now in observing a great quantity of sections, transverse, longitudinal and tangential a certain regularity is evident. The meshes are for the greater part square. As a rule the six fibres forming the longitudinal, concentric and radial systems, meet at approximately right angles.

Among the siliceous Sponges there is a large family characterised by the hexactinellid structure of the skeleton. Most of them have a solid skeleton, the elements of which are sex-radiate spicules, besides this however they possess free sex-radiate spicules. Among the Sponges that are destitute of self-produced siliceous elements Fritz Müller found the first sex-radiate horny spicules. *Velinea* is an interesting example of a Sponge possessing a solid hexactinellid horny skeleton. According to F. E. Schulze[1] the whole skeleton-fibre of *Euspongia* is a secretion of modified cells of the connective tissue. The axis is the first production, the concentrical layers of »spongin« are formed afterwards, but both are secretions of the spongoblasts. According to Marshall and Schmidt the fibres take their origin from simply modified »sarcodine«. In his studies on Hexactinellids Marshall says that in one case the network of sarcodine (»Sarcodine-gitterwerk«) is enveloped by horny material, in another case by silica (Hexactinellids). The first we find in Hornsponges; as examples Marshall mentioned *Luffaria* Duch. et Mich. and *Aplysina* O. S. Had he known our Sponge, he would probably be still more convinced of his hypothesis; we now know a Hornsponge with sex-radiate free spicules and another with a rather regular sex-radiate skeleton. Marshall's hypothesis seems to be no more than that. Whether there is really a close relation between the two mentioned groups is for the moment not yet made out, because we do not know how the skeleton developes. Marshall's supposition is ingenious, but not entirely true, because he did not know of the existence of spongoblasts.

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[1] F. E. Schulze, Zeitschr. f. wiss. Zool. XXXII. p. 635.

Now that we know the anatomy of *Velinea* we can pass to the study of the tissues. As in all known Sponges the mass of the body consists of connective tissue, inclosed by epithelium. The whole outer surface is covered by flat epithelium-cells. The centra of these cells are rather far one from another (fig. 3); this makes the layer resemble the ectodermal epithelium of *Sycandra raphanus*[1]. I could not see distinct limits between these cells and so I was not able to decide whether there is a rather hyaline plasma in the outer parts of the cells and a granular part aggregated around the nucleus in the centre of the cells, or whether the cells consist solely of the granular part lying in a copious secondary substance, secreted by the cells. A comparison with the epithelial layer of other Sponges, for instance *Sycandra*, would be an argument in favour of the first view; but it ought to be remembered that the limits of the granular mass is in our sponge much more distinct than in *Sycandra* according to SCHULZE's pictures. This, and the fact that the hyaline substance stains very little, are on the contrary arguments of the latter view. Fresh material is wanted for deciding this question.

The same kind of epithelial cells seems to line all efferent and afferent canals. Some of the lacunae in the spongeous soft mass, that is in the cloacal tubes are perhaps without this epithelium; at least there was frequently no trace of it at all. In fig. 10 I have drawn some cells of the epithelium lining the cloacal tube. As I have said those of the external layer do not differ from them, they are more or less oval-shaped, possess many highly refringent granules and a round or oval nucleus with finer granules and a darkly stained nucleolus. The collar cells have no peculiar character, except their small size. The connective tissue consists of a hyaline mass in which are to be seen beautiful granulated cells with long branching processes, by means of which they are hanging together in order to form a fine network (fig. 14). The nuclei are not very conspicuous. Very often vacuoles are visible. These ordinary cells of connective-tissue assume different shapes. In the deeper parts the processes are more numerous than in the parts nearer the canals. There the majority are spindle-shaped. In fig. 14 I have joined together some typical forms that all occur in the deeper parts. In some places they are more contracted, as in fig. 15. I cannot say whether these have another function or not. Something like spongoblasts I have not found; nor could I detect eggs or spermatozoids. Nothing of the curious sperm-

[1] See F. E. SCHULZE, Zeitschr. f. wiss. Zool. XXV. Suppl. Bd. plate XIX.

cells, lately described by Polejaeff [1] were visible, although I am well acquainted with their appearance.

I mentioned the fact that I could not see spongoblasts. This is however no reason at all that the skeleton of *Velinea* should develop in another way. One must not forget that only one specimen, preserved in spirit, was at my disposal. — The fibres consist of a pith-substance (Marksubstanz) and concentric layers of Spongin around it. This pith-substance has not always the same diameter, but there is always a trace of it. Sometimes the outer spongin-layer has stained clearly while the pith has remained yellowish. In that case the difference is very well seen on transverse sections; but often the colour diminishes gradually towards the centre. In fig. 11 the pith is visible, although not at first sight; in fig. 12 it is very conspicuous. The cells in the fibres, as von Lendenfeld has described in some *Aplysinidae*, seem not to occur. The fibres resemble much more those of *Spongelia* than of *Aplysina* or *Aplysilla*. The curious yellow highly refractive corpuscles, described by Oscar Schmidt and F. E. Schulze in *Euspongia* were abundant in *Velinea* (fig. 11 and 12). It is remarkable that they occur sometimes in the pith (fig. 12) at other times between the spongin-layers (fig. 11). I do not know what these corpuscles are. No trace of plasma or nucleus was to be seen. I showed my preparations to Dr. Karl Brandt and asked him whether he had ever seen »yellow cells« resembling these corpuscles. He answered that they had nothing to do with them. In fig. 13 I have made a picture of a fibre that has been boiled in Eau de Javelle. There are no yellow corpuscles to be seen; this is perhaps because they are not present since they can resist for a long time the action of reagents.

As regards the systematic position of *Velinea*, I believe it to be nearly allied to *Spongelia*.

It will be necessary to consider the whole group of those Sponges which excepting the horny skeleton do not produce any other substance for strengthening it, viz. of the so-called Hornsponges.

For the moment there are to be distinguished four groups of Hornsponges. In the first place we have the family of the *Aplysinidae*, characterised by the fact that the fibres of the skeleton possess nearly always a thick axis-substance and are without foreign corpuscles; in

[1] Polejaeff, Sitzungsber. Ak. Wiss. Wien. Bd. LXXXVI, p. 276—298. I have seen these cells in many other sponges. I showed my sections to Dr. Polejaeff, who was kind enough to study them; he told me that I had been right in identifying the cells in question.

the second place there is the family of the *Spongidae*, possessing numerous sand particles etc. at least in the main fibres. Between these stands the genus *Spongelia*, having as the *Spongidae* many sand particles in the hornfibres, but being distinguished from them by the shape of the ciliated chambers and the whole arrangement of the canalsystem. The genera *Hircinia* F. E. S. and *Oligoceras* F. E. S. may easily be brought into a fourth family, characterised by the well known filaments.

Now it is clear after my description that *Velinea*, wanting the filaments does not belong to the *Hircinidae*, as I propose to call the fourth family. The *Spongidae* so well described by F. E. SCHULZE are characterised by him as follows: »Geißel-Kammern halbkugelig und klein, mit besonderem Ausführungsgange versehen und von einem körnchenreichen Bindegewebe umgeben, das Skelet aus einem Netze solider, concentrisch geschichteter, hier und da fremde Körper, aber niemals eigene Kieselbildungen enthaltender Sponginfasern (bestehend).... Filamente (fehlend)«. Evidently *Velinea* cannot be placed in this group. So there is only a question whether it is to be placed under the *Aplysinidae* or united with *Spongelia* in a new family.

VON LENDENFELD [1] has split up SCHULZE's *Aplysinidae* into two sub-families, *Aplysininae* and *Aplysillinae*, and has given as character for the original family the want of foreign corpuscles in the fibres and the presence of a central axis-substance. The whole arrangement of the canalsystem in the two sub-families is a quite different one; this difference seems to me to be important enough to give these sub-families the value of families. And on the other hand the want of foreign bodies in the skeleton-fibres and the presence of an axis-substance are not important enough to be adopted as a family-characteristic. In the *Spongidae*, *Hircinidae* and in *Spongelia* we see that not all fibres have sand particles; in the second place we see that an axis is nearly always, perhaps always present. Even within the family of the *Aplysinidae* F. E. S. there are all possible transitions between the thin-walled fibres of *Aplysina* and the thick-walled ones of *Janthella*. For the moment I think we may distinguish three families: *Aplysinidae* s. str., *Aplysillinae* v. Lendenf., for which I should like to write *Aplysillidae* [2]; and *Spongelidae*. The canalsystems of *Verongia* Bwk., *Dendrospongia* Hyatt, *Darwinella* F. Müll. and *Janthella* Gray are still unknown. So we cannot

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[1] VON LENDENFELD, Zeitschr. f. wiss. Zool. XXXVIII. Bd. 1883. p. 235.

[2] According to the Stricklandian Rule that names of families ought to terminate in *-idae*, those of sub-families in *-inae*.

determine for the moment whether they must be placed in the family of the *Aplysinidae* or of the *Aplysillidae*; but in the arrangement of the skeletons *Verongia*, *Janthella* and *Dendrospongia* show more resemblance to one another and to *Aplysina* than to *Darwinella*. This genus on the other hand seems to be closely allied to *Aplysilla*. In the family of the *Aplysinidae* I place *Aplysina* and probably the three mentioned above. In the *Aplysillidae* I will place *Aplysilla* and *Dendrilla*, probably also *Darwinella*[1]. The family of the *Spongelidae* appears to be characterised by the strong network of fibres, by the thin axis-substance in the fibres, and by the great pouch-shaped ciliated chambers. The genus *Spongelia* itself has in the main fibres numerous particles of sand; *Velinea* wants this. Thus we can make the following tabular view:

fam. I. Aplysinidae. (s. str.) ciliated chambers not very large, pear-shaped. Ultimate ramifications of the exhalant and inhalant canalsystem thin. Skeleton more or less regular network of anastomosing fibres. Walls of the fibres thin; axis-substance thick; no sand. Groundsubstance granular.

Aplysina: probably also: *Verongia*, *Dendrospongia*, *Janthella*.

fam. II. Aplysillidae. (= *Aplysillinae* v. Lendenf.) ciliated chambers large, pouch-shaped. Communication of inhalant canals and lacunae with the chambers by means of numerous pores in the latter. Communication of exhalant canals and lacunae with the chambers by means of one wide mouth. Fibres tree-like ramified, not anastomosing. Axis of fibres rather thick: all fibres without sand; groundsubstance without granules.

Aplysilla, *Dendrilla;* probably also *Darwinella*.

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[1] Merejkowski has asserted in his »Etudes sur les Eponges de la Mer Blanche« (Mém. Acad. Imp. Sc. St. Pétersbourg. VII. Sér. T. XXVI. No. 7; Separ. Copy p. 43), that the name *Aplysilla* F. E. S. was to be changed in his *Simplicella*, for reasons of priority. As a matter of fact we know the following. In 1877 Merejkowski presented a preliminary note to the Committee of the Society of Naturalists, St. Petersburg. The paper was accepted and should be printed in the same year. But unfortunately »la faute de la typographie l'a empêchée de paraître dans le huitième volume«; the result was that the paper appeared in 1878, the same year in which Schulze's »*Aplysinidae*« came out. So both names date from 1878, and Merejkowski can never be right in changing. We prefer Schulze's name because »*Aplysilla*« is well described and figured, while of »*Simplicella*« there is hardly a diagnose in the prelimary account; besides his note is written in Russian. So it follows, as well as from the above mentioned facts, that Merejkowski's name *Darwinellidae* cannot be used, but in stead of it *Aplysillidae*.

fam. III. Spongelidae. Ciliated chambers large, pouch-shaped. Communication of inhalant canals and lacunae with the chambers by means of numerous pores in the latter. Communication of exhalant canals and lacunae with the chambers by means of one wide mouth. Fibres anastomosing in order to form a regular or irregular network. Axis of fibres thin; main fibres often with sand; groundsubstance without granules.

Spongelia, *Velinea*.

fam. IV. Spongidae. Ciliated chambers small, hemispherical. Communication of inhalant canals and lacunae with the chambers by means of numerous pores in the latter. Communication of exhalant canals and lacunae with the chambers by means of special wide canals. Fibres anastomosing in order to form an irregular network. Axis of fibres hardly visible. Main fibres often with sand; groundsubstance in the neighbourhood of the ciliated chambers with numerous granules. No filaments.

Euspongia, *Cacospongia*, *Phyllospongia*, *Carteriospongia*, *Stelospongia*.

fam. V. Hircinidae. Ciliated chambers small, hemispherical. Communication of inhalant canals with the chambers by means of numerous pores in the latter. Communication of exhalant canals with the chambers by means of special canals. Fibres anastomosing in order to form an irregular network. Axis of fibres hardly visible. Main fibres always, the other fibres often with sand and other foreign corpuscles. Groundsubstance in the neighbourhood of the ciliated chambers with numerous granules. Between the skeleton-fibres numerous filaments.

Hircinia, *Oligoceras*.

The following analytical list may be useful for determination:

1 a. Skeleton-fibres anastomosing 2
b. Skeleton-fibres not anastomosing; tree-like ramified, (or sex-radiate) . . . . . fam. *Aplysillidae*.
2 a. No filaments 3
b. Numerous filaments . . . . . fam. *Hircinidae*.
3 a. Groundsubstance between the ciliated chambers granular . . 4

b. Groundsubstance between the ciliated chambers not granular . . . . . 5. (fam. *Spongelidae*).

4a. Skeleton formed by a more or less regular network of concentric layers; axis-substance of the fibres abundant; without sand . . . . . fam. *Aplysinidae*.

b. Skeleton formed by an irregular network; axis-substance hardly visible; main fibres nearly always with sand. Wide canals and lacunae . . . . . fam. *Spongidae*.

5a. No sand in the fibres; skeleton rather regular . . . . *Velinea*.

b. Main fibres with much sand; skeleton not very regular *Spongelia*.

The diagnosis of the genus *Velinea* may be given as follows: skeleton formed by a regular (sex-radiate) network of spongin-fibres that are destitute of sand or other foreign siliceous, or calcareous bodies. The shape of the ciliated chambers and the arrangement of the canalsystem have the character of the family *Spongelidae*.

The name *Velinea*, arose in the following manner. I had named this sponge *Evelina* but afterwards seeing that this name had already been appropriated, I transposed the letters.

Explanation of Figures.

Plate 31.

(The object is preserved in strong alcohol and stained with borax-carmine. I used Microsc. HARTNACK; Cam. luc. of ZEISS-OBERHÄUSER; Immersion of SEIBERT & KRAFT.)

Fig. 1. *Velinea gracilis* n. g.; n. sp. Nat. size.

Fig. 2. Surface, seen with a pocket-lens.

Fig. 3. Epithelium of the outer parts. *p* pores. HARTN. VII.

Fig. 4. Transverse section. Combination of two or three following sections. *s.d.c.* subdermal cavity; *i.c.* inhalant canal; *e.c.* exhalant canal. Some of the ciliated chambers are cut, others are intact, showing the chamber pores. HARTN. III, cam. luc. projected on the level of the object stage

Figs. 5 and 6. Sections of ciliated chambers in communication with the canals Letters as above mentioned. HARTN. IV, ocul. tube extended. Proj. obj stage.

Figs. 7, 8 and 9. Different shapes of ciliated chambers. HARTN. IV, tube extended Proj. obj. stage.

Fig. 10. Epithelium-cells lining the cloacal tube. Imm. VII. Ocul. 3. Proj. obj. stage

Fig. 11. Transverse section of skeleton-fibre. Imm. VII etc. as in fig. 10.

Fig. 12. Longitudinal section of id. Magnif. id. id.

Fig. 13. Longitudinal section of id. after having been treated by Eau de Javelle Magnif. as in 12.

Fig. 14. Cells from connective tissue. Imm. VII. etc. as in fig. 10.
Fig. 15. Contracted (modified?) cell of connective tissue. Imm. VII. Oc. 3. Proj. working table.

Plate 32.

Fig. 16, 17, 18. Transverse section; half-diagrammatic. The connective tissue is yellow; the epithelial cells are black, the skeleton elements blue. HARTN. II, cam. luc. proj. obj. stage.
Fig. 19. Longitudinal section of the top of a cloacal tube; half-diagrammatic. Colours as in fig. 16 etc. Showing the distribution of the ciliated chambers and the soft inner mass wanting all skeleton. *s.d.c.* subdermal cavity. HARTN. II; cam. luc. proj. obj. stage.
Fig. 20. Transverse section. As in fig. 16.
Fig. 21. Longitudinal section of cloacal tube. The yellow lines are the skeleton-fibres. The inner wall of the tube is covered by the soft white mass. Magnif. pocket-lens.
Fig. 22. Transverse section of skeleton, showing the regular mashes. HARTN. II, cam. luc. proj. obj. stage.
Fig. 23. Longitudinal section of id. On the right side is the outer part. HARTN. II, cam. luc. proj. obj. stage.

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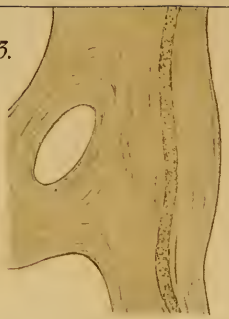

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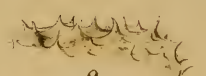

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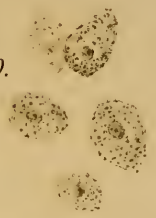

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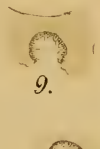

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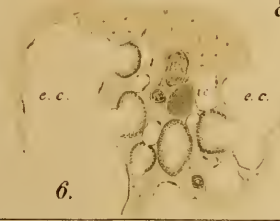

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