beneath very pale, almost white. Five dark violet stripes, a mesial and two pairs of lateral, extending along the entire length of the dorsal surface. The mesial stripe narrow and linear, the succeeding pair broad and band-like, and the outermost pair again linear. The outermost pair placed at a short distance from the lateral margin of the upper surface, and the band-like pair at half the distance between these and the central stripe. Just behind the head the two lateral bands on either side fuse together, and form a pair of broad dark patches.

Faint and narrow violet stripes mark the margin of the ambulacral line on the under surface of the body.

Length of the single specimen 9 inches; extreme breadth of the body $\frac{1}{7}$ inch, of the head $\frac{1}{5}$ inch.

Exeter College, Oxford,
Feb. 18, 1878.

XXIX.—*Studies on the Hydroida.* By C. Mereschkowsky.

[Plates XIII., XIV. & XV.]

I. *Morphological Considerations.*

The human mind has not the power of retaining in its memory the representations of all the concrete objects which are presented to its five senses; for the number of these objects and of facts is too immense for its faculties, which are still so imperfectly developed. But, at the same time, the mind desires to be in possession of as many facts as possible; hence the tendency to generalization and the double character of every science: on the one hand, we have concrete facts without any bond between them, without any idea, serving only as raw material; on the other, generalizations, more or less abstract ideas. Not only every science, but even every branch of each science, every group of events or facts, may therefore have its philosophy—that is to say, its generalizations, its ideas, its laws which govern the facts.

The usefulness of these laws or generalizations, even in the case of small groups of events, cannot be doubted; in reality it is often only by taking advantage of them that a thinker can arrive at generalizations of a higher degree, without the necessity of busying himself in the midst of thousands of little facts and minute details.

In the following pages I shall speak of a group of facts which may be observed among the Hydromedusæ, and which may be generalized into a single idea, a single *law of metamerism* (*Metamerengesetz*) or of *articulation*. This law may be formulated as follows:—*The Hydroid may be composed of two or several metameres, similar or not; each metamere in its turn is composed of several antimeres.*

Fig. 1 shows diagrammatically a Hydroid belonging to what I call the *articulate type*; it will be seen that it consists of three very distinct metameres, each of which is in its turn composed of four antimeres*.

This law governs a considerable number of forms among the Hydromedusæ; we may recognize it in the species belonging to various genera—for example, in *Stauridium*, *Coryne*,

Fig. 2.

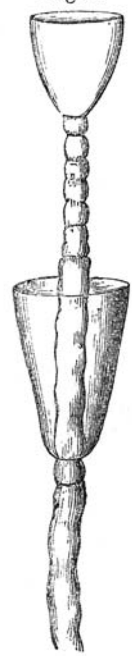
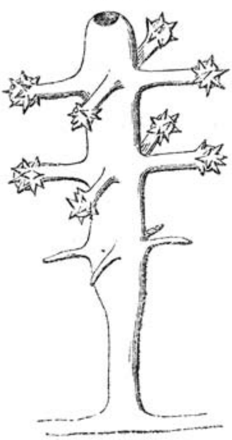


Fig. 1.



Syncoryne, *Millepora*, *Cladonema*, *Tubularia*, *Cordylophora*, *Gemmaria*, &c.; but all the cases in which we remark the articulate type among the Hydromedusæ belong exclusively to the order of naked Hydroids (Athecata). There is not a single Hydroid belonging to the order Thecaphora which

* According to M. E. Häckel we should have to call such a type "*forma staurastoma diplopola articulata.*"

has the least normal tendency to the production of metameres*.

The number of metameres is very variable in different genera and species. We know several Hydroids (as, for example, *Cladonema radiatum*) which have only two metameres, usually, in this case, very distinct and well marked. Up to the present time we do not know a single Hydroid which has three distinct metameres; but we know one with four very clearly developed; this is *Stauridium productum*, which I have found in the White Sea. After it come the forms which have more than four metameres; but in these cases they are not very distinct, and their number is no longer constant, but varies with the age and development of the individual. At the same time, this variation in the number of metameres takes place within certain limits; for there are species in which the metameres never attain the great number met with in other species.

Among the forms which are very rich in metameres I can cite several, but especially *Coryne pusilla* and *Gemmaria implexa*, in which we may see a very great quantity of metameres. It is true that in such cases it is impossible to fix clearly the boundaries of two metameres, and that it is often impossible to decide whether two tentacles belong to one or to two different metameres; but nevertheless it is easy to see that we have to do with the same articulate type as in *Stauridium* and *Cladonema*; only here the order of arrangement of the tentacles, in consequence of their great number, has become very much effaced.

As to the nature (*das Wesen*) of the *law of metamerism*, the cause which has produced the articulate type among the Hydroids, I think I am justified in explaining it in the following manner:—The Hydroid, in consequence of a great abundance of nourishment, or from some other cause unknown, began to grow in the direction of the primary axis of its body. Growth, as we know, does not differ generically from the process of multiplication; the latter is only a particular case of the former; and the two processes depend greatly upon each other.

The growth of the Hydroid beyond its specific limit causes

* A single anomalous fact is known to me in the Thecaphora, in which there appears a tendency, although a very feeble one, to take on the articulate form. This is the *Clytia poterium*, Agassiz (fig. 2), in which one hydrotheca is placed above another, which has produced it, no doubt, by division. But this case can only be regarded as an anomaly, the normal individuals never having any trace of metamerism. This anomaly has been described by Agassiz, 'Contributions to the Natural History of the United States,' iv. p. 303, pl. xxix. fig. 1.

multiplication by means of incomplete transverse division (*unvollständige Quertheilung*)—that is to say, the appearance of one or several new systems of secondary axes, which are all, at first, in accordance with the law of heredity, equal among themselves and to the first axial system from which they have proceeded. But instead of separating from each other and entering upon a free and independent life, as we see in a very analogous process of gemmation in the *Scyphistoma* of the Discophorous Medusæ (fig. 3)*, each system of secondary axes remains connected with a small community and leads a social life (fig. 4).

In order to demonstrate that this view is correct, and that the articulate type is nothing more than the product of an incomplete transverse division, we may consider the singular anomaly presented by *Clytia poterium*, Ag. (fig. 2). There is no doubt that this form is produced by increase of growth, which for its part produces a transverse division analogous to that which takes place in the *Scyphistoma*, but with the difference that here the superior articulation does not separate from the colony, because the division is incomplete. But if we imagine the Hydroid deprived of its calycle we shall have fundamentally the same picture that is presented by the digrammatic figure of an articulate Hydroid in fig. 1.

Let us now consider fig. 5, which represents, after Mr. Hincks†, the interesting Hydroid *Vorticlava proteus*. Owing to its great contractility it can take on different forms; and one of them (fig. 5), in which the superior metamere is removed to a great distance from the inferior metamere, and in which the two articulations are united only by a long and very thin peduncle, proves very clearly that the metameres are true articulations produced by incomplete division. Just the same thing (that is to say, the great individuality of each metamere, united only by a fine peduncle) occurs also in *Corymorpha pendula*, Agass.‡; only the individuality of the metameres is unequal, being easy to see in some Hydroids (such as *Vorticlava*, *Stauridium*, and *Cladonema*), and more or less effaced in others with many metameres (*Zanclea*, *Coryne*, &c.). But in any case we must regard the articulate type as a small colony.

The number of individuals in such a community may be

* Each tentacle (each antimere), or rather each pair of antimeres, is nothing but an axis vertical to the axis of the body (principal or primary axis), which is ordinarily called a secondary axis. The different types of Hydroids have 1, 2, 3, 4 n, ... secondary axes, *i. e.* 2, 2×2, 2×3, 2×4, $2\times n$ tentacles.

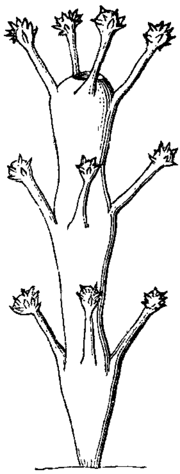
† Mon. Brit. Hydr. vol. ii. pl. xxiii. fig. 2, *d*.

‡ Contrib. Nat. Hist. Un. States, vol. iv. pl. xxvi. figs. 14 and 17.

considerable, as we have already seen, about ten or even more; and, in fact, it is most usual for their number to exceed four or five.

Fig. 3.

Fig. 4.



In these cases, and especially where we have to do with about ten metameres, the explanation of the origin of these articulated forms which I have just given cannot suffice; and hence it must be supplemented by a very interesting law, which Prof. N. Wagner of St. Petersburg has denominated the *law of physiological inertia*, and has so happily applied to the explanation of the incredible number of metameres (articulations) with which various worms (Annelida) are furnished.

Fig. 5.

According to this law, some cause having originated two or three metameres, the appearance of the following metameres may be brought about without the further aid of the primary cause, but solely under the influence of a tendency that the organism has to repeat the process of the appearance of metameres (a process at first induced by some external influence [*choque*], such as abundance of food) by *inertia*, as it were, until finally resistance, under different forms, may put a stop to it.

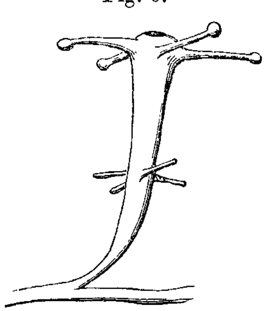
The different qualities and properties of an organism are often retained, by force of heredity, without interruption and without modification during a long series of generations, even when the cause which has induced these qualities has long disappeared. It is so in the case in question: a certain cause has induced in the organism the tendency to grow constantly in length by incomplete transverse division; and if it happens that this cause acts for a long time, through a long series of generations, it is easy to understand that this tendency may acquire so great a persistency, and may become so powerful, that it will continue to manifest itself even after the disappearance of the original cause. Considered from this point of view, the *law of physiological inertia* appears simply to be a particular case of another more general law—the law of heredity; and I believe that if we apply this law (without which the phenomena of the Annelida are perfectly obscure and incapable of explanation) to the group of Hydroids, and especially to the articulate type, we shall attain the possibility of explaining and understanding the appearance of such forms as *Coryne pusilla* and *Gemmaria implexa.*

In the articulate type there is a peculiarity which is very interesting, especially because it can be very clearly explained, and to which I wish to call attention, namely the form of the tentacles. One of the most characteristic features which always accompany the law of metamerism in the Hydroids, is the capitate form of the tentacles, which in this case, are always very short (figs. 1, 4). This peculiarity of the articulate forms is especially observable in the species with numerous metameres, in which the tentacles are excessively short. There are very few exceptions to the rule that articulation is combined with the capitate form of tentacles; and nearly all these exceptions can be perfectly well explained.

In seeking to explain this fact, and to find the cause of its occurrence (*raison d'être*), we must first of all call attention to the coexistence of the two facts, articulation and capitate tentacles, and inquire whether this singular and invariable coexistence is not due to a causal relation between the two facts. It is more than probable that this is the case; and, as we shall see immediately, it is the articulation that is the cause of the form of the tentacles.

The articulate type has no doubt originated from the non-articulate type with 4, or, in general, $2\times n$ filiform tentacles. The tentacles of this general type ($2\times n$) are:—1, usually rather long and slender, not capitate, endowed with great contractility; and, 2, covered over all their surface with a quantity of thread-cells. Such an organization is adapted to subserve two functions at once—namely, (1) seizure of food, and (2) defence against enemies by means of the venomous thread-cells. When the Hydroids furnished with metameres began to be developed from this type thus constructed and non-articulate, and, at the same time, the length of the whole animal increased considerably, so that the long, slender, original tentacles, which previously extended beyond the apex of the body (where the mouth is placed), became relatively shorter, they would no longer reach the buccal orifice, which would deprive them of all power of acting as organs of nutrition. This must certainly take place, especially with the lowest tentacles. The part which they performed being thus diminished, and their significance in the economy of the animal changed, the tentacles would no doubt undergo, if not complete atrophy, at least a considerable diminution in their development. This is, in fact, what we observe. In such articulate forms as *Cladonema radiatum* (fig. 6), for example, which is furnished with two very distinct metameres, we remark that the four lower tentacles, belonging to the inferior metamere, are too short to reach the mouth, and consequently cannot possibly assist in the process of nutrition; at the same time they are much less developed, much shorter and more delicate than the other four tentacles belonging to the upper metamere, which can very easily reach the mouth.

Fig. 6.



The form with four metameres (*Stauridium productum*) shows us the same thing. In this also the four tentacles of the inferior metamere are, to a very great degree, atrophied*. The same thing takes place in all the other articulate forms, even when the number of metameres is very considerable, as, for example, in *Coryne pusilla* and *Gemmaria implexa*. In all cases the inferior tentacles are less developed, half or one third of the length of those of the superior metameres, and the more they approach towards the basal extremity of the body the shorter they are, so that in the lowest regions the length of the tentacle often does not exceed its thickness; but the superior tentacles, as well as the inferior, are comparatively much shorter in the articulate than in the non-articulate type. This atrophy of organs evidently depends upon a diminution

* We know no form governed by the law of metamerism having 3 metameres; but it is easy to see that such a form must once have existed, and that it, perhaps, still exists in some little-investigated sea. If it be found some day, we may predict with great probability, from the evidence of the forms with 2 and 4 metameres, that it will also have 4 tentacles (or $2\times n$) belonging to the inferior circle more atrophied than the rest. The genus *Triridium*, to which this hypothetical Hydroid must belong, is represented in fig. 1.

of their utility to the organism; for in the articulate type the tentacles, instead of fulfilling two functions at once, only perform one, namely that of defence against enemies. At the same time it has become possible for the organ to adapt itself better to the single function of defence than before, when it required also to capture food; it has attained the possibility of retaining the characters which are only useful for defence and which are even injurious to prehension. It is precisely this possibility of adapting themselves to the single function of defence that is the cause of the tentacles in the articulate type being very short and capitate at their extremity.

Imagine now a Hydroid reposing after a full meal, with its tentacles quietly expanded in the water and gently moved to and fro by the waves. When any enemy approaches it with hostile intentions and is inclined to attack it, the assailant must most certainly strike against the ends of the tentacles before it can touch the body of the Hydroid. Upon the effect produced by this first contact with the ends of the tentacles will depend all the subsequent actions of the enemy: if it receives a very strong charge it will be killed on the spot, or will make its escape as quickly as possible; in the contrary case, when the pain caused by the thread-cells arranged in the ends of tentacles is too insignificant, the enemy may arrive at the very body of the Hydroid, which is then menaced with great danger. We see, therefore, that, for the purpose of self-preservation, it is very important that the first line of fortifications, so to speak, should be as strong as possible—in other words, that the ends of the tentacles should be as formidably armed as possible, that there should be as many thread-cells as possible in these ends; for those which are placed in the other parts of the body and tentacles are not of equal importance for the purpose of defence. To fulfil all these conditions it is clear that the tentacles must be inflated at their extremities, in order that a great quantity of thread-cells may be accumulated in the enlargement. When once these tentacles have ceased to act as organs of prehension, it is no longer necessary that they should be long, fine, supple, and movable; this is why in the articulate type, at the same time that they acquire the capitate form, they also become much shorter than usual.

It generally happens that in those cases in which the body becomes very much elongated it acquires great flexibility and the faculty of twisting about very briskly, and so assists the proboscis in the capture of food, whilst, on the other hand, this organ in such cases also becomes strongly developed and very mobile. This flexibility of the body consequently replaces the want of tentacles for the function of alimentation, as is very well shown in fig. 5, p. 64, of the 'History of British Hydroid Zoophytes' by Mr. Hincks, as well as by the description which accompanies it*. In the Hydroids without metameres, in which the body is consequently very short and not flexible, the tentacles are always filiform, long, fine, and very supple; their length sometimes even becomes very great, as, for example, in *Monobrachium parasitum*, mihi†, which has only a single tentacle.

This, then, is the explanation that, I think, may be given of the fact that the articulate type of the Hydroids is associated with short and capitate tentacles.

This view is further supported by the fact that the capitate tentacles are exclusively met with in the order Athecata, or the Gymnoblastic Hydroids—that is to say, among the naked Hydroids,—and that, on the contrary, in the order Thecaphora, in which each hydranth is furnished with a hydrotheca or calycle of chitine within which it can entirely withdraw itself, and which often may even be closed by a small operculum, we only find filiform tentacles. This is very easily explained, seeing that these Hydroids, which are very well defended from all attacks of their enemies by the hydrothecæ, within which they can conceal themselves in case of danger, have no necessity for organs so well designed for defence as are the capitate tentacles. On the other hand, as the Thecaphora grow in very numerous colonies, the number of individuals sometimes exceeding 1000, it is necessary for them to adapt themselves to the possibility of procuring food in sufficient quantity for so great a number of individuals living together. This adaptation in the case in question consists in the number of long, fine, filiform tentacles appropriated to prehension with which each individual is provided becoming very great, greater than it usually is in the naked Hydroids. (There are generally not fewer than 16, most frequently 20, 22, 24, and sometimes 30, 32, or more.)

Finally, I may mention another fact, which will serve in

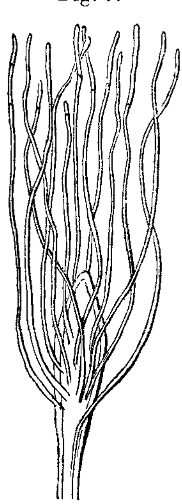
* In fact the flexibility of the body of such Hydroids as *Cladonema radiatum*, *Stauridium productum*, and others is excessively developed, and may very well compensate for the want of filiform tentacles in the function of prehension of nourishment. But it is especially in *Clavatella prolifera* that the length, contractility, and flexibility of the body have attained their maximum; and it is, I think, by this cause that we may explain why it also has capitate tentacles, although not belonging to the articulate type. It furnishes the only example of capitate tentacles in a non-articulate type.

† See my paper, "On a new Genus of Hydroids from the White Sea," in this journal for September 1877, ser. 4, vol. xx. p. 220.

support of the explanation above given of the forms with capitate tentacles. I refer to the blastostyles of the genus *Hydractinia.* It is well known that the gonophores, or sexual individuals, appear upon the surface of the body of the trophosomes, or nutritive individuals, which are furnished with several filiform tentacles. When these gonophores appear, the individual upon which they are seated, and which is then called a "blastostyle," becomes much thinner and smaller (the material of the animal being absorbed by the sexual bodies), the mouth closes, and the tentacles (which, from this moment lose their importance as organs subserving the purpose of nutrition, since the mouthless individual cannot feed) become shorter and shorter and more and more insignificant. Soon we can only perceive a few knobs or tubercles furnished with a great quantity of thread-cells, greatly resembling the dilatations with which the capitate tentacles are furnished. At the same time these tentacles or tubercles only retain the function of defence from enemies.

But I have said that there are exceptions to the rule that articulation is associated with capitate tentacles, and that these exceptions are not contradictory to the explanation that I have given; on the contrary, it is possible to explain these exceptions only by admitting all that I have said above.

Fig. 7.



Cordylophora lacustris.

There are some forms, evidently belonging to the articulate type, which do not possess capitate tentacles, but, on the contrary, have those organs slender, filiform, and very long. For example, *Clava**, *Cordylophora*, &c. (especially *Cordylophora*) have tentacles longer than in any other species. This is to be explained as follows:—In becoming developed into the articulate type the Hydroid became more and more elongated, whilst the tentacles remained the same, which rendered them relatively shorter; and it is precisely this that induced their capitate form. But if we assume that all the time the elongation of the tentacles proceeded side by side with the elongation of the body, we shall see that their original significance, as aiding in alimentation at the same time as for defence,

* Especially *Clava leptostyla*, Ag. (A. Agassiz, Illustr. Cat. Mus. Comp. Zool. ii. p. 170, fig. 274). In the cases in which the tentacles are not too long we may admit that these species have only become articulate

must remain intact; for in proportion as the body became elongated, the tentacles lengthened likewise, so that they could always reach the mouth and convey food to it (fig. 7).

But if the functions of the tentacles did not undergo any change, we need not expect them to change their form, except perhaps to become longer. This is what we remark in such forms as *Cordylophora*, *Clava*, &c., in which the lowest tentacles are not in the least shorter or less developed than the upper ones; on the contrary, they are sometimes a little longer; and in all cases they are all, without exception, longer than the body, owing to which they all have the faculty of assisting in the capture of prey, as has been very well described by Van Beneden in the case of *Cordylophora**.

I must still mention an articulate type, represented by the genera *Tubularia*, *Acharadria*, *Corymorpha*, *Pennaria*, &c., in which the superior metamere has the tentacles capitate, but much less developed than those of the other metamere. All these forms are derived from a non-articulate form with tentacles so well developed, so long, and in such *great quantity*, that when the formation of the second metamere was induced by some cause, the tentacles belonging to it were perfectly useless to the organism, which caused them to become atrophied, and at the same time capitate—that is to say, adapted solely to the defence of the organism (fig. 8). As the Medusa may be regarded as a hydranth reversed, and in which the tentacles (radial canals) are united together by a gelatinous substance (ectoderm or bell), it may be understood that the Medusæ which have tentacles at the extremity of the manubrium belong to the same articulate type as *Tubularia*, *Acharadria*, &c., with two metameres, the inferior of which is more strongly marked than the upper.

Fig. 8.

Acharadria larynx.

To complete this morphological chapter I propose to explain in a few words a point of view from which I regard all the

quite recently, and that they are in process of forming capitate tentacles, or of lengthening them. Thus Mr. Allman remarks, "Some Hydroids with filiform tentacles show, like *Clava squamata*, a tendency to the terminal enlargement of the tentacles in certain states of contraction" (Allman, Mon. Gymnobl. Hydr. p. 245).

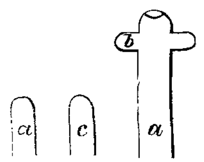
* Van Beneden, 'Faune littorale de Belgique,' Polypes.

forms and in general all the morphological facts presented by the Hydroids, and which I think may contribute somewhat to the better comprehension of the idea of the Hydroid, so to speak, and to concentrate all the differences presented by this group in a single representation.

Every one at present regards a hydranth, with its tentacles, as a single individual, furnished with organs radially arranged. For my part, I believe we must regard such an organism, not as an individual, but as a colony composed of two kinds of individuals—the one kind appropriated to the function of seizing food, with the gastral cavity but slightly developed, without a mouth, very flexible and thin (*tentacles*); the other destined exclusively to nourish the whole colony, furnished with a mouth, and with a large cavity in the body which is but slightly flexible (*the actual body of the hydranth*). We should thus have a polymorphic colony after the fashion of the Siphonophora; and this polymorphism is explained here also by adaptation to different functions by the division of labour. Certainly before this division of labour was effected the colony only consisted of similar individuals, produced from the parent individual by gemmation; and it was then that the individuality of each individual must have been most strongly marked; but in course of time, in proportion as the division of labour was effected, this individuality was effaced, and the whole acquired more or less the character of a single individual furnished with several organs. This is what we see now-a-days. Therefore, in saying that the hydranth must be regarded not as an individual but as a polymorphic colony, I do not wish by any means to say that each tentacle is a true individual, but only that it has been so formerly, and that it has retained [this character] in part even to the present day. I may, moreover, urge the enormous difference which exists between the organ tentacle and the organs of other animals —a foot, for example, and still more the hand of man; this difference is profound and primordial (*principielle*), because a hand (or, in general, any organ) is not homologous with a tentacle, and is only analogous to it in its physiological function.

Such a view as this would perfectly explain the origin of the organ tentacles, which would be merely the result of the reproduction of a *Protohydra*, Leuck., or rather an *Archhydra*, Häck., by the process of gemmation. From this point of view, therefore, I must give the name of individual to each *axis* of cylindrical form, composed of ectoderm and endoderm; and it is very remarkable that any Hydroid, however complicated it may be, appeared at first precisely in the form of a cylinder with a single diplopolar axis, in this respect differing in no way from the first appearance of a tentacle upon a hydranth, or of a medusa. In fact it is impossible to distinguish a tentacle, a medusa, and a hydranth at the first moment of their appearance (fig. 9); each of them is merely an *Archhydra* or a *Protohydra*, which, if we accept the biogenetic law, leads us to believe that they are all different modifications of a single primitive organism, and that they are all homologous.

Fig. 9.



a. Young hydrotheca.
b. Young tentacle.
c. Young medusa.

At any rate, I believe that to regard a (stauraxonic) hydranth as a colony of (monaxonic) *Archydræ* is to look at the affair as it is fundamentally.

Let us further remember two interesting Hydroids, namely *Ophiodes mirabilis** and *Ophiodes parasiticus*, Sars†, which, besides the tentaculiferous individuals (colonies according to me), have monaxonic individuals, without tentacles, and absolutely presenting no difference from the tentacles of certain Hydroids. And this case proves further that the tentacle (an individual), which cannot serve the colony either by procuring or by digesting food, only remains useful to it by serving to defend it, a function which induced the capitate form of the tentacles. In fact, the monaxonic individuals have no mouth, and therefore do not aid in nutrition; and, at the same time, they are often placed so far from the colony-individuals that they cannot serve for seizing food. The function of defence, therefore, alone remains for them; and we find that they have acquired the capitate form, which we have seen to be appropriated to defence.

II. *Remarks on the Reproduction of* Obelia flabellata, *Hincks.*

Among about forty species of Hydroids that I have observed and collected in the White Sea, *Obelia flabellata*, Hincks, is very frequently met with. At the end of the month of June I found it with a great quantity of gonothecæ, all filled with young Medusæ in various stages of development. Although in all other respects the *Obelia flabellata* of the

* Hincks, Mon. Brit. Hydr. Zooph. pl. xlv. fig. 2, p. 231.

† G. Sars, "Bidr. til Kundsk. om Norges Hydroider," Förh. i Vidensk. Selsk. i Christiania, 1873, p. 109, pl. iv. figs. 5–8.

White Sea did not differ at all from that described by Hincks*, the gonotheca was distinguished by the absence of the little tubular elevation placed upon its flattened summit, of which I never observed any trace; nevertheless it can only be regarded as a feeble arctic variety of the British *Obelia flabellata.*

The development of the Medusæ has been studied principally by L. Agassiz†, who was the first to publish some important facts, and by F. E. Schultze‡, as well as by Mr. Allman (the last on *Corymorpha nutans*), who have made some alterations in the views current before their time. But as most attention has been paid to the Medusæ belonging to the order Athecata, I have thought that it might not be altogether without interest to have their results confirmed by a Medusa belonging to the quite different order Thecaphora.

Plate XIII. fig. 1 shows the first commencement of a Medusa, which only consists of a protuberance (expulsion) of the walls of the blastostyle, composed, like the latter, of two layers, the ectoderm and endoderm, separated from one another by a very thin layer, which is not so distinctly contoured as in the buds; it is, no doubt, the hyaline intermediate layer between the ectoderm and endoderm which Schultze calls the "Stützlamelle." In form, this bud differs in no respect from a young hydranth developed from a planula; and both have exactly the same form as *Protohydra Leuckartii*, Greef, and the same as must have been possessed by Häckel's *Archhydra*§, *i. e.* if we choose to accept Häckel's biogenetic law. The next stage is represented in fig. 2 (Pl. XIII.); we see that the bud has considerably widened, and that the ectoderm (which is here also distinctly separated from the endoderm by the double-contoured line) has become much thicker at the summit of the bud than elsewhere. The thick part, which is in the form of a cone, is turned downwards towards the endoderm, in which the cone buries itself; the inner surface of the endoderm and also the general cavity of the body retain their original form: they do not form any expulsion; and their apex is always hemispherical. But, at the same time, we already remark that the depression of the outer surface of the endoderm is not a regular cone, but, on the contrary, that the edges of this depression are dentate. There are four teeth formed by the superior layer of the endoderm, and between these teeth four depressions occupied by the inferior layer of the ectoderm. It

* 'History of British Hydroid Zoophytes,' i. p. 157.
† 'Contributions.'
‡ 'Ueber den Bau der *Syncoryne Sarsii*,' 1873, p. 27.
§ It is his form "monaxonia diplopola inarticulata."

is easy to see that the first stage consists in the depression of the ectoderm (it is the latter that is active here), and that the first indications of radial canals are not the result of the *expulsion* of the endoderm into the ectoderm, but, on the contrary, of the *impulsion* of the ectoderm into the endoderm. The latter continues quite passive; it submits to the action of the ectoderm, which of itself begins to thicken, and by this means to bury itself in the endoderm. The following stages (figs. 3, 4, and 5) are only the more advanced stages of the process which we have already analyzed: the ectoderm becomes more and more developed, at the same time that it buries itself in the interior, leaving in their place only the four spots, which thus become converted into radial canals. In fig. 3 the apex of the cavity is already excavated, and there are faint indications of the four canals (only two are represented); but speedily this cavity again becomes convex, and it is from this moment only that the endoderm becomes active; it thickens in the middle (fig. 4), and begins in its turn to penetrate the ectoderm in order to form the manubrium. In fig. 5 we see the same stage with the four canals. It will be seen that between the two neighbouring canals there is only a uniform layer of ectoderm in which they are immersed, which proves that F. Schultze is right in not admitting any intermediate layer between the canals and distinct from the ectoderm, as was done by Agassiz. After all this, according to F. Schultze, the ectoderm itself splits into two layers, one of which produces the muscular sac belonging to the umbrella, and the other forms the superior layer of the manubrium*. Unfortunately various circumstances drew me away from these observations; so that I have not seen the stage intermediate between fig. 5 and fig. 6, in which the Medusa is ready to detach itself.

As the Medusa of *Obelia flabellata* is, so far as I know, undescribed, I will give a short account of it. Pl. XIII. fig. 7 represents a mature example, and shows that this Medusa differs very little from other Medusæ of the same genus, as, for example, that of *Obelia dichotoma* figured by Hincks †. The umbrella is very flat, but slightly campanulate, without thread-cells, with four radial canals, four oval sporosacs filled with ova and placed at the extremities of the four canals, where they unite with the circular canal, and where conse-

* By this the development of the Medusa of *Obelia flabellata* differs from that of *Corymorpha nutans*, in which the division of the ectoderm takes place sooner, as early as the first indications of the radial canals (Allman, Monogr. Gymnobl. Hydr. p. 77).

† *Loc. cit.* pl. xxviii. fig. 1, *c*, *d*.

quently the nutritive material attains its maximum abundance; for here the current of the radial canal unites with the current of the circular canal. The margin of the Medusa is furnished with eight lithocysts and a great quantity (more than thirty) of short tentacles, which are only sixteen in number at the moment of liberation. The manubrium is short, changes much in form, and is furnished at its orifice with four rounded lobes. The size is very variable, but it is usually about 6 millims. in diameter. It is completely colourless, whitish; the sporosacs are slightly yellowish. By leaving in a marine aquarium a branch of *Obelia flabellata* with gonothecæ, one can always obtain as many Medusæ as one wants. Fig. 7 *a* shows a Medusa of the natural size.

The ova are large, of irregular form (Pl. XIII. figs. 8, 9, 10), with a very thin membrane and granular contents. In the middle, or more frequently near the margin, we always observe very distinctly a large, clear and non-granular nucleus, more regular than the ovum itself. In the nucleus we always observe one or several nucleoli, and in each nucleolus a nucleolulus. All these formations are distinguished from each other by their behaviour with transmitted light; when the first of them is lighter, the second is darker, and the third again lighter. On changing a little the focal distance of the microscope all is changed; what was dark becomes lighter, and *vice versâ*. In the youngest ova we see only one nucleolus and one nucleolulus (fig. 8); the latter is usually very variable in its form, which is most frequently irregular. Sometimes it is very large (fig. 11, representing a nucleus very much enlarged). Further, we see ova in which the nucleolus has acquired a biscuit-shape, in each half of which we observe a nucleolulus which has evidently divided into two (figs. 9, 14). A subsequent stage may be seen in fig. 10, in which the nucleolus is completely divided and each half contains a nucleolulus. A still more advanced stage shows (fig. 12) a nucleus with four nucleoli, each containing a nucleolulus, which is very large and variable in form. The form changed before my eyes with considerable rapidity, and the whole moved like a little *Amœba*. Lastly, the succeeding stage that I have been able to observe (fig. 13) is furnished with a nucleus with a great quantity (about twenty) of nucleoli, almost every one of which contained a very small nucleolulus, which, however, it was sometimes impossible to define.

It is evident that all these nucleoli have originated from a single one by division, and that this division was always preceded by the division of the nucleolulus into two. Only once I observed in a perfectly round nucleolus more than one nucleolulus, or rather a single nucleolulus in the centre surrounded by five or six very small granules forming an aureole round the centre.

As I observed all these stages of development in ova which had not issued from the sporosac, and, moreover, there was not a male individual in the neighbourhood, all the processes described took place in ova not yet fecundated. It would be interesting to know why there is all this enormous complication. But as yet the facts are too few to permit us even to think of an explanation.

Lastly, this hydroid has offered me another interesting fact which I will mention. For the purpose of observing the development of the Medusæ I placed a branch of *Obelia flabellata* upon a slide, and laid over it a covering-glass; the sea water by evaporating became salter and salter, which (and perhaps also the want of oxygen) appeared to affect the organism in a singular manner. In a short time I remarked that the cœnosarc of the stem detached itself in fragments of different sizes, especially near the end. First of all there appeared a constriction in a particular spot; this constriction became deeper and deeper; and finally the two parts separated entirely, so that the end of the stem formed a fragment quite independent of the colony. The two parts contracted, moved away from each other, and became rounded at their ends, so as to leave no trace of their lesion (Pl. XIII. fig. 16); the ectoderm and the endoderm recurved at the newly formed end just in the same way as in the end of the stem: the cavity was very distinct; and I could even observe the movement of nutritive granules, which I also saw in perfectly fresh specimens. Except wanting the mouth and cilia, this little cylinder much resembled a planula. In fig. 17 is represented a hydrotheca not yet completely developed, closed at its future aperture, in which the cœnosarc is contracted, not into a cylinder, but into a perfectly regular globular form, with a cavity, and surrounded by two layers. At one spot a very fine and colourless membrane, evidently produced by the ball, is seen to detach itself; this, no doubt, is a new layer of perisarc formed by the ectoderm; and I believe that in the other cases the perisarc is also present, but that in them it adheres very closely, for which reason it cannot be perceived.

What is the signification of these structures? For what purpose are they formed? Is it not a sort of encysting, analogous to the process so often met with among the Infusoria? Are not these fragments of the Hydroid the result of its dismemberment, caused by the evaporation of the water?

and is it not their function to survive these unfavourable conditions and thus serve, not only for the preservation of the individual, but also for propagation?

I think we may answer all these questions in the affirmative, and regard these fragments as formations analogous to what is known to us from Prof. Allman's * observations on the spontaneous fission of *Schizocladium ramosum* and *Corymorpha nutans*, as a means of reproduction by fission. In *Schizocladium ramosum* the upper portion of a branch becomes detached as a little cylinder, just in the same way as in *Obelia flabellata*; and then, after having ruptured the perisarc, this free portion departs from the colony, forms the perisarc again, and becomes transformed into an individual.

[To be continued.]

PROCEEDINGS OF LEARNED SOCIETIES.

GEOLOGICAL SOCIETY.

April 11th, 1877.—Prof. P. Martin Duncan, M.B., F.R.S., President, in the Chair.

The following communications were read:—

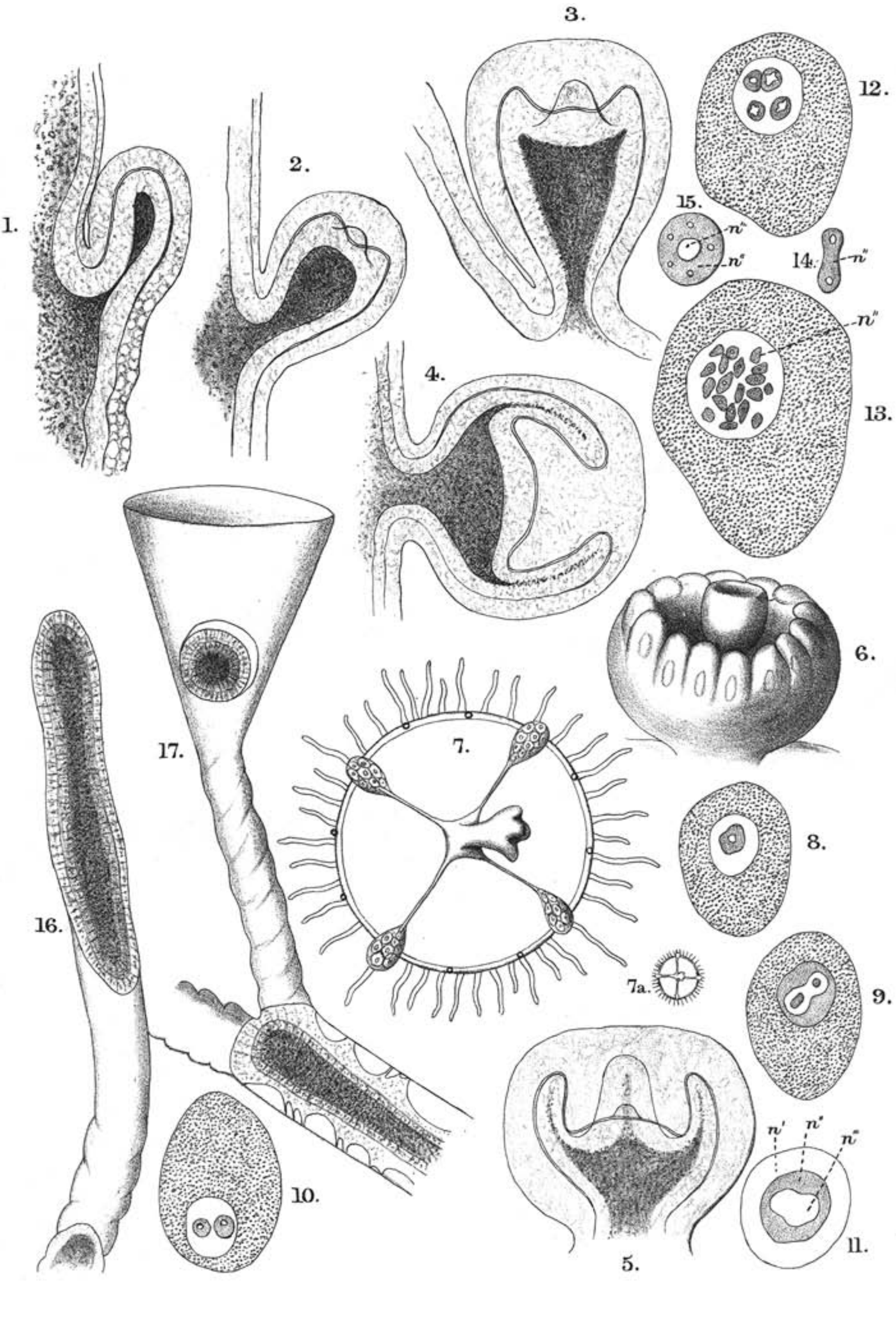
2. "The Bone-caves of Creswell Crags."—Third Paper. By the Rev. J. Magens Mello, M.A., F.G.S.

In this paper the author gave an account of the continued exploration of these caves, and of the completion of the examination of the Robin-Hood Cave, noticed in his previous communications. Five deposits could be distinguished in the Robin-Hood Cave, namely, when all present:—

1. Stalagmite, 2 ft.
2. Breccia, with bones and flint implements, 1 ft. 6 in.
3. Cave-earth, with bones and implements, 1 ft. 9 in.
4. Mottled bed, with bones and implements, 2 ft.
5. Red sand, with bones and quartzite implements, 3 ft.

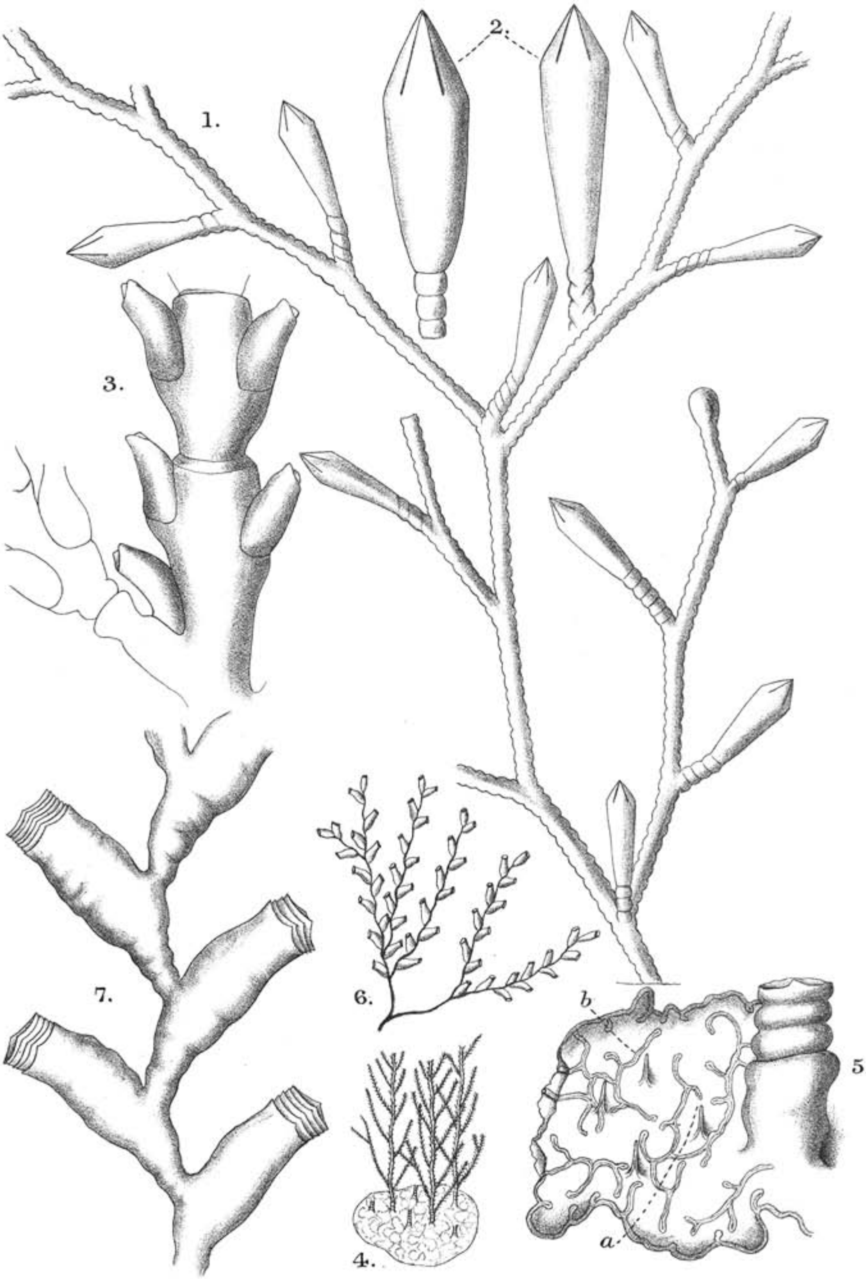
Variations both in thickness and in character occur in different parts of the cave. The surface-soil yielded traces of Romano-British occupation, such as enamelled bronze fibulæ, fragments of pottery, &c. The most important discoveries were made in the cave-earth; and chief among these was a fragment of bone, having on it a well executed outline of the head and neck of a horse, the first recorded discovery of any such work of art in this country. The cave-earth also yielded a canine of *Machairodus latidens*, hitherto obtained in England only in Kent's-Hole. Numerous remains of the Pleistocene Mammalia already recorded were found, together with a great

* Allman, "Reproduction by Fission in Hydroids," Brit. Assoc. Report, 1870; and Quart. Journ. Micr. Sci. 1871, pl. ii. figs. 2, 3.



R. Mintern lith.

Mintern Bros. imp.



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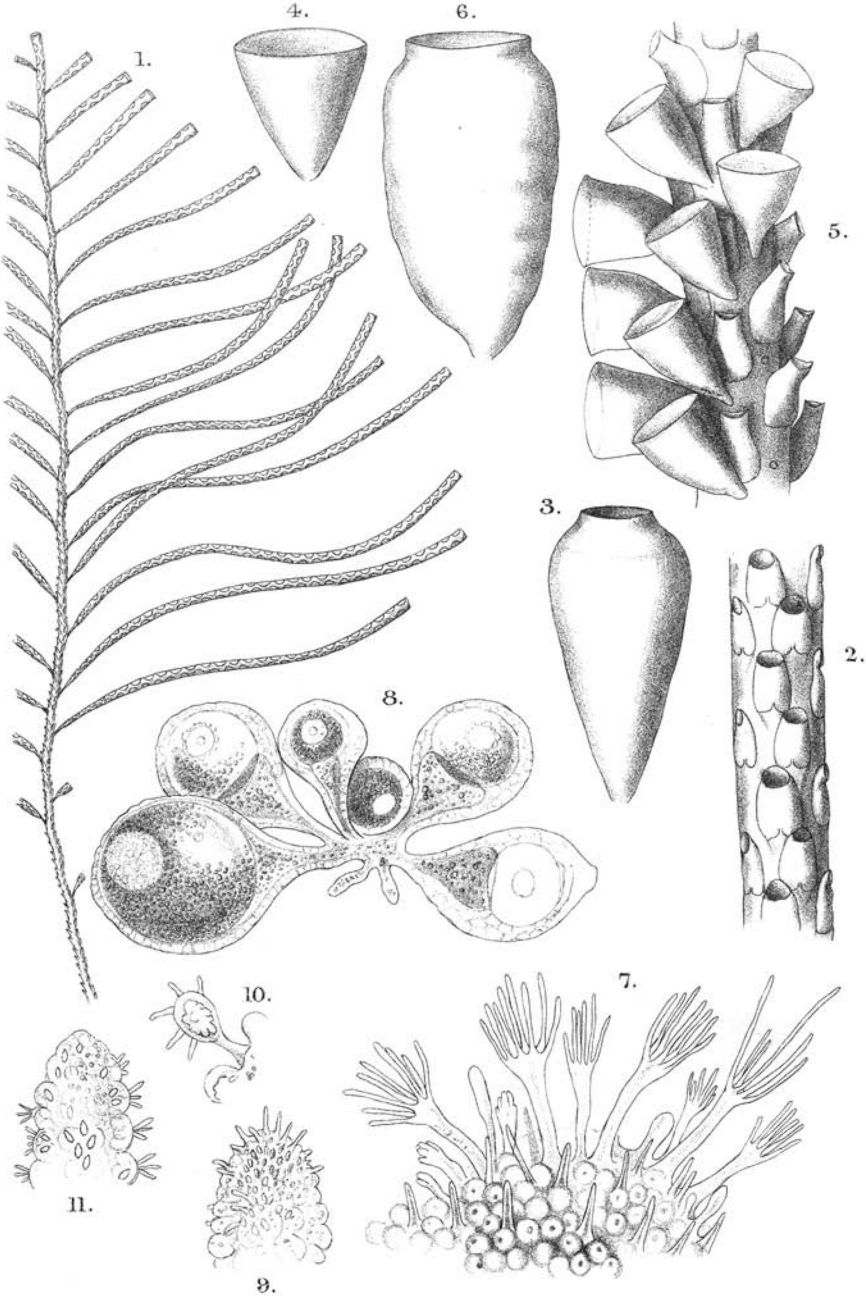

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