section, which will speedily render it transparent. As soon as this is the case, the oil of cloves should be removed as far as possible, in the same way as the alcohol. A small quantity will of course remain behind. A drop of Dammar varnish should now be let fall on the section, and a covering glass applied, when the preparation will be finished. It is better to put a piece of tissue paper, with a hole punched in the centre, under the covering-glass. It becomes soaked through with varnish, and adheres to the slide and cover. If this paper be not used in preparations of early stages, the weight of the covering glass is very apt to crush the section, and spoil it before the varnish has had time to set.

By cutting sections of sufficiently advanced embryos at right angles to the long axis of the body, very interesting preparations illustrative of the development of the sense organs may be obtained.

I have ventured to describe these methods at such length here, because they are applicable not only to the frog's egg, but also with slight modifications to all the finer histological problems, such as the retina, the organ of taste, the Schneiderian membrane, and Corti's organ.

A paper in Max Schultze's 'Archiv,' 1869, erstes heft, by Dr. A. Goethe, on the development of *Bombinator igneus*, will be found very useful by those working up the subject. The plates are very clear, and there is no difference of any moment between this animal's development and that of the frog. Consult also Rathke's 'Entwickelungs-geschichte der Natter,' Königsberg, 1839; Reichert 'Das Entwicklungsleben im Wirbelthierreich,' Berlin, 1840; Remak 'Untersuchungen über d. Entwickelung der Wirbelthiere,' Berlin, 1855; 'Vogt. Unters. ü. d. Entwickelung der Geburtshelferkröte,' Solothurn., 1842.

On some Interesting Points *concerning the* Mode *of* Reproduction *of the* Bryozoa. By Dr. Hinrich Nitsche, of Leipzig.

A great many papers on Bryozoa have been published, but since the majority of them give mere descriptions of the various external forms of the colonies and single cells, our knowledge of the anatomy, histology, and mode of reproduction of these interesting animals is still very limited. A great advance as regards the latter point, the reproduc-

tion, is due to the researches made by Smitt a few years since. In his interesting paper "Om Hafbryozoernas utveckling koch fettkroppar,"[1] Smitt registers many new facts of such a nature as to throw quite unexpected light on the evolution of the Bryozoa. Every reader must be astonished by the immense store of precious observations accumulated on a few pages of Smitt's memoir; but the conclusions and theories based upon these observations seem to be not always quite as correct as would be expected from so skilful and learned a naturalist.

My own interpretation of some facts observed by Smitt, and afterwards by myself, differing in some respects from his, I shall try to give a preliminary sketch of my views upon this subject, hoping to be able to give very soon a more elaborate account of a series of inquiries made by myself about the anatomy of some marine Chilostomata.

Smitt distinguishes four modes of reproduction in the Bryozoa, three of them taking place in an asexual way.

1. The growth of the whole colony by external buds. 2. The reproduction by eggs formed by internal buds of the endocyst. 3. The production of new polypides and eggs in empty zoœcia or cells, by "groddkapslar," *i. e.* by brown bodies produced by a retrogressive metamorphosis of the former polypide. 4. Sexual reproduction by eggs and spermatozoa.

Smitt believes that the growth of the colonies by external buds is effected in a very peculiar manner, differing from this process in all other compound animals. He observed that very often young buds, seeming at first to be equivalent to a single zoœcium, become afterwards divided by longitudinal and transversal septa, each partition transforming itself into a perfect zoœcium or an homologue of such (an avicularium, vibracularium, &c.).

Such buds he designates as "samknoppar," *i. e.* "common buds," produced not by a single cell, by a single individual, but by the whole colony. To this view he has been, I think, principally led by his observation on the budding process of Flustra membranacea. Certainly every one is able to satisfy himself very easily that often one, at first simple bud, is afterwards divided into different zoœcia, or into a zoœcium, avicularium, and vibracularium; such buds are very properly designated as "common buds," but they always are the offspring of *one* mother-cell.

Such "common buds" are always produced when a crust-like colony expands. The radiating arrangement of the cells in most of the crust-like colonies, together with the fact that

[1] 'Oefversigt af Kongl. Vet. Akad. Förh.,' 1865, No. 1.

the breadth of the single cells is limited, though variable, makes it a necessity that at different times new series of zoœcia become interpolated, the colony otherwise acquiring a lobed outline. This interpolation of a new series of cells or zoœcia is effected in this way, viz., that a zoœcium instead of producing one zoœcium at its anterior edge produces two, both of them originating from an at first simple bud—a *common bud*, by secondary division. The same process often takes place when in an arborescent colony a twig dichotomizes.

That a "common bud" is produced by two or more mother cells, or by the margin of the whole colony, I never was able to observe, and it is also difficult to agree with this doctrine from a theoretical point of view, since it is quite incompatible with the scientific conception of the individual in so highly organised a class, that many of them should unite to the production of one bud in common.

A careful examination of many colonies of Flustra membranacea[1] gave me the conviction that also in this species a "common bud," in the meaning given to this designation by Smitt, does not exist.

The increase of the colonies of Flustra membranacea during the summer is a very rapid one, and the growing margin shows a very peculiar appearance. A marginal zone, of sometimes an inch in breadth, contains not fully developed zoœcia, but only more or less immature ones. The immature cells, which are nearest to the centre of the colony, are principally distinguished by the more imperfect calcification of the ectocyst, and the smaller size of the polypides. The still younger and more eccentrically situated cells do not show any calcification at all, the two posterior spines of the cell are represented only by small rounded knobs, and the opercular opening in the ectocyst not yet opened, and consequently the very small polypides are not yet able to become protruded. In the last zone of distinct cells every zoœcium consist of a quadrangular depressed bag surrounded by a tough chitinous membrane lined with a layer of cells, and showing at its posterior wall a small knoblike polypide bud.

[1] Smitt gives in his admirable paper, "Kritisk förteckning öfver Skandinaviens Hafs-Bryozoer," 'Oefversigt af Kongl. Vet. Akad. Förh.,' 1867, No. 5, p. 357, the following diagnosis of this species:

Fl. membranacea (Lin. Sol.).

Char.—Colonia in crustæ formam expansa zoœcia ad angulos distales (*i.e.*, juniores exteriores) setâ brevi mucronata praebet. Avicularia et oœcia desunt.

But I have satisfied myself that the two spines Smitt attributes to the distal part of the cell belong really to the proximal, *i.e.*, the older part of the cell.

But even these latter zoœcia are not the outermost components of the colony; from the anterior wall of each of them originates a long slender flattened tube of the same breadth, but two or three times as long as a normal cell. These tubes are surrounded by a very delicate chitinous membrane, and lined with a layer of prismatic cells. Smith having in some cases overlooked the longitudinal septa between the different tubes, believes this zone to form at first an undivided flattened expansion surrounded by a membrane, and filled with "adipose corpuscula" (so he calls, in this case, the prismatic cells which secrete the endocyst); but this is, I think, a mistake, and the appearance of an undivided margin is caused only by the fact that the chitinous membrane is very transparent, and the single tubes are in very close juxtaposition.

The examination of specimens preserved in spirit and especially transverse sections made from this part of the colony, show very clearly that the longitudinal septa are always present from the beginning. The marginal zone of Flustra membranacea is, therefore, not to be regarded as a "common bud" of the whole colony, but as an aggregation of many "common buds" produced by single zoœcia, every tube being really a "common bud" in the way I should like this name to be understood. Indeed, every tube is equivalent to two or three zoœcia, into which it is afterwards divided by secondary transversal septa.

The most curious and interesting mode of evolution Smitt attributes to the Bryozoa, is the so-called reproduction by "groddkapslar," *i. e.* "germ capsules." Every one who has studied the anatomy of marine Bryozoa is well acquainted with the fact that only a very small part of the little cells of which every colony consists contains completely developed polypides; whilst the younger cells at the edges of the colonies enclose immature buds, the eldest cells are either quite destitute of polypides and contain nothing only circular or oval, sometimes also irregularly-shaped brown bodies or these said bodies together with a new budding polypide. Only the intermediate cells between the youngest and the eldest show completely developed polypides. These brown bodies, lying in the interior of the cells of this part of the colony, which was formerly believed to be in a state of decay from want of polypides, have been mistaken very often for true ova. Smitt having witnessed many times the true ova of different species, rejects wholly this opinion, and states quite correctly that these brown bodies are products of the decomposition of the polypide formerly lodged in the cell; but the fact that they are often found associated together with a new bud of a

polypide, forces upon him the conviction that this new bud is the descendent of the brown body; therefore he designates this body as "groddkapsel," "a germ capsule," produced in an asexual way, and showing much affinity in function with the statoblasts of the Phylactolæmata.

Professor Claparède, in his late paper,[1] devotes a separate chapter to the discussion of this mode of reproduction. This very conscientious zoologist does not agree with the views of Smitt; he believes that the brown bodies are not the result of a retrogressive metamorphosis of the polypide formerly contained in the lodge, but a secretion of the endocyst, and that the real products of this retrogressive metamorphosis are the things which Smitt looks upon as young buds produced by the groddkapslar,—the retrogressive metamophosis taking place in such a way that the polypide, having attained its maturity, passes anew but in inverse order through all the stages through which it has passed during its development. The process he supposes to take place is, therefore, the same a flower would undergo if, after having fully expanded, it should close again and retransform itself into a bud, vanishing by and bye by gradual diminution.

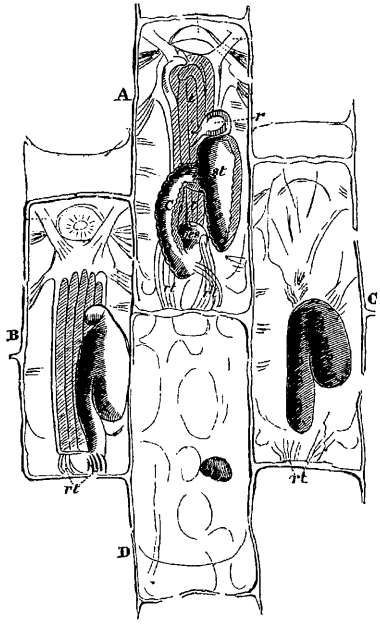
Professor Claparède was kind enough to express in his paper a regret that I had not put forward my opinion about the point in question, and being now able to do so, I will not delay to comply with his wishes.

One of the species which furnished to Smitt the evidence that the "groddkapslar" are the result of a decomposition of the polypides, is Flustra membranacea. This author gives also a drawing of some zoœcia of this species whose polypides are decaying, but it is so minute, and the description of the process itself so very laconic, that it is not very persuasive, and a more accurate drawing seems to be required. The cells in the interior of a colony of Flustra membranacea are, in most cases, provided with polypides, but a closer inspection shows that scattered over the whole colony there are groups of a few cells containing decaying polypides; such a group is represented by the adjoined woodcut.

A still stronger evidence of the correctness of the views of Smitt about the origin of the brown bodies is offered by the circumstance that it is very often possible to distinguish in the interior of them distinct remains of the food swallowed by the polypides when living, especially the siliceous tests of diatomaceous algae and radiolarian animals, a fact utterly incompatible with the suggestion of Claparède that the brown

[1] 'Zeitschrift für wissenschaftl. Zoologie,' xxi, p. 147.

bodies are secretions of the endocyst. But these facts speak just as strongly against the supposition that they are in any



In the cell A, the polypide is still intact in its ordinary state of retraction. In the lodge B, the polypide is so strongly retracted that the base of the tentacular crown almost touches the posterior wall of the cell; the tentacula exhibit some signs of commencing decomposition. In the third cell C the tentacular crown, together with the tentacular sheath and the œsophagus, have disappeared. The great retractors are still preserved, but their anterior point of attachment having vanished, they project freely into the cavity of the cell. The remains of the polypide form a bilobed bag, whose narrower portion consists of the cardiac portion of the decaying intestine, the bigger one corresponding with the cœcum. In the last lodge D the retractors too have disappeared, and the remains of the polypide are transformed into a brown body filled with granular substance, and surrounded by a tough membrane, the only trace of its former shape being the faint bilobation it shows.

way concerned in the reproduction of a new polypide in the deserted cell, or of an egg. I have satisfied myself that the new buds found associated in a cell with a brown body take their origin from the endocyst, just in the same way in which the first polypide was produced by the budding of the endocyst at the time when the cell did not yet occupy its actual position, but was a still immature bud without calcareous skeleton in the margin of the colony. The fact that both buds and brown bodies are often found in close contact does not furnish any proof of a correlation between them, that is, of the existence of a generative link; it is merely caused by the circumstance that whilst the first polypide-bud in every cell originates in the angle formed by the posterior and upper wall of the cell, the second bud originates in the centre of the upper wall, and the brown body occupies the centre of the lodge. The occasional occurrence of two "groddkapslar" in one lodge, which Smith has witnessed in some species, is very easily explained by the supposition that the secondary polypide too has undergone the retrogressive metamorphosis.

A further proof that the appearance of a new polypide in a lodge is in no way connected with the presence of a "groddkapsel," is afforded by Alcyonidium hispidum. "Groddkapslar" are also found in the older cells of this species, but the formation of a new bud is not delayed till the retrogressive metamorphosis of the polypide occupying the cell has become complete; it takes place by the budding of the endocyst in the centre of the upper wall of the cell at a much earlier period, when the polypide, though already altered, in general still retains its former shape.

I have satisfied myself (1) that the "brown bodies," being in no way endowed with any reproductive function, are mere remains of decaying polypides. (2) That the vitality of the zoœcia does not all depend upon the presence of a polypide, and that a zoœcium having lost its polypide can produce a new one by an internal budding of its endocyst.

The facts just recorded speak very much in favour of the views many years ago stated by Allman,[1] and newly again advanced by Reichert,[2] who seems to ignore completely that they are not at all a novelty, though he is acquainted with the monograph of Allman, viz., that the polypide is not to be considered as a mere organ of the Bryozoon, but as a distinct zooïd produced in an asexual way by another zooïd,

[1] 'A Monograph of the Fresh-water Polyzoa,' p. 41.

[2] "Vergleichende Anatomische Untersuchungen über Zoobotryon pellucidus," 'Aus den Abhandlungen der Königl. Akademie der Wissenchaften zu Berlin,' 1869. Berlin, 1870, p. 238.

the zoœcium, or cell. To this view of Allman I must completely assent, though I cannot go so far as to regard likewise the ovarium and the testis as distinct zooïds.

Indeed I look upon every colony of "Bryozoa entoprocta"[1] as being a compound animal ("Thierstock"), composed of two different classes of zooïds, the "cystoid zooïds" and the "polypoid zooïds." The cystoid zooïds assume very different shapes, their various forms causing the great diversity of the external form of the Bryozoa. In this group are to be reckoned—

1. The cœnœcium of the Phylactolæmata, showing not yet separated lodges (Lophopus), and the cells or zoœcia of the Phylactolæmata with distinct lodges, Chilostomata, Ctenostomata, and Cyclostomata.
2. The avicularia of the Chilostomata.
3. The ovicells or oœcia of the Chilostomata.
4. The vibracularia of the Chilostomata.
5. The stem-joints of the Vesiculariadæ.
6. A part of the spines and root filaments of the Chilostomata and Ctenostomata (?).

The primary zooïd of every colony is a cystoid zooïd produced by a direct metamorphosis of a ciliated larva.

The polypoïd zooïds are always produced by a process of budding from the inner side of the endocyst of a cystoid zooïd; but since only the two first-mentioned modifications of cystoid zooïds are endowed with the faculty of producing polypoid buds, there are only two forms of polypoid zooïds:

1. The common polypide, generally considered as the intestinal apparatus, and the tentacular crown of the polyzoon.
2. The round bodies, bearing a brush of sensible setæ, in the avicularia of some species.[2]

The cystoid zooïds are intrusted with the whole amount of reproductive functions, both sexual and asexual, the polypoid zooïds providing for the nutritition, the respiration, and the sensitive functions, the functions of the polypides of the avicularia being limited to the latter function.

Lastly, I must state that I cannot find any adequate reason to regard the so-called "nervous system of the colony" as a true nervous organ.

A more elaborate account of the facts leading me to this conviction I shall give in a subsequent paper.

LEIPZIG, 1st February, 1871.

[1] H. Nitsche, 'Beiträge zur Kenntniss d. Bryozoen. Zeitschrift für Wissenschaftliche Zoologie,' v. xx, p. 34.

[2] Busk, "On Avicularia," 'Quarterly Journal of Microscopical Science,' New Series, Vol. II, 1854, p. 26, Pl. II.