

**Experiments on Cleavage in the Egg of
Cerebratulus.**

By

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Introduction

Unconscious of ZELENY'S work on the nemertine egg ('04), which had been carried on a few months before at Naples, I took up a similar problem in the summer of 1903 at South Harpswell, Maine and arrived at results ('04) which agree in the main with his. However, as regards the cleavage factors incidentally described in my paper, some difference is found between his results and mine. In order partly to clear up the discrepancy and partly to promote our knowledge of cleavage-physiology, more experiments were made upon the egg of both *Cerebratulus lacteus* and *C. marginatus* in the summers of 1904, '05 and '07 at the Harpswell Laboratory, and in the spring of 1906 at the Naples Zoological Station.¹ In the present paper I shall deal with the results attained from those experiments and the conclusions to be derived from them.

1 The work of the years 1905 and '06 was carried out on a grant from the CARNEGIE Institution of Washington. My best thanks are due to Professor J. S. KINGSLEY of the Harpswell Laboratory and to the late Professor A. DOHRN and the staff of the Naples Zoological Station.

I. Experiment A (*C. lacteus*).

This series of experiments consists in cutting off a portion of cytoplasm from the egg along oblique planes¹ at different periods extending from the formation of the first polocyte to the beginning of the first cleavage (*cf.* WILSON '03, p. 430). Twenty seven eggs were thus experimented on and the early cleavage stages were studied. Without giving the record of each case, the results may be summarized as follows: (a) the cleavage of twelve eggs operated on between the formation of the first and second polocyte was regular (Figs. 1-4). In two eggs out of twelve the cleavage went on somewhat irregularly with regard to the arrangement of the blastomeres. This was undoubtedly due to the temperature, which was unusually high on the day the two eggs were operated on; (b) of fifteen eggs cut between the formation of the second polocyte and the first cleavage, nine divided regularly, while the rest cleaved abnormally regarding both size-relation and rhythm (Figs. 5-7).

From this experiment it will be seen that in the egg of *C. lacteus* the mode of cleavage is disturbed by the removal of a portion of cytoplasm in a short period preceding the first cleavage. The statement I made in a previous paper, that enucleated fragments taken before the first division cleaved always regularly ('04, pp. 134-135, 136), is, therefore, not altogether correct and should be modified as just stated.

¹ Since horizontal cut is liable to cause normal cleavage, oblique sections were purposely performed in this series.

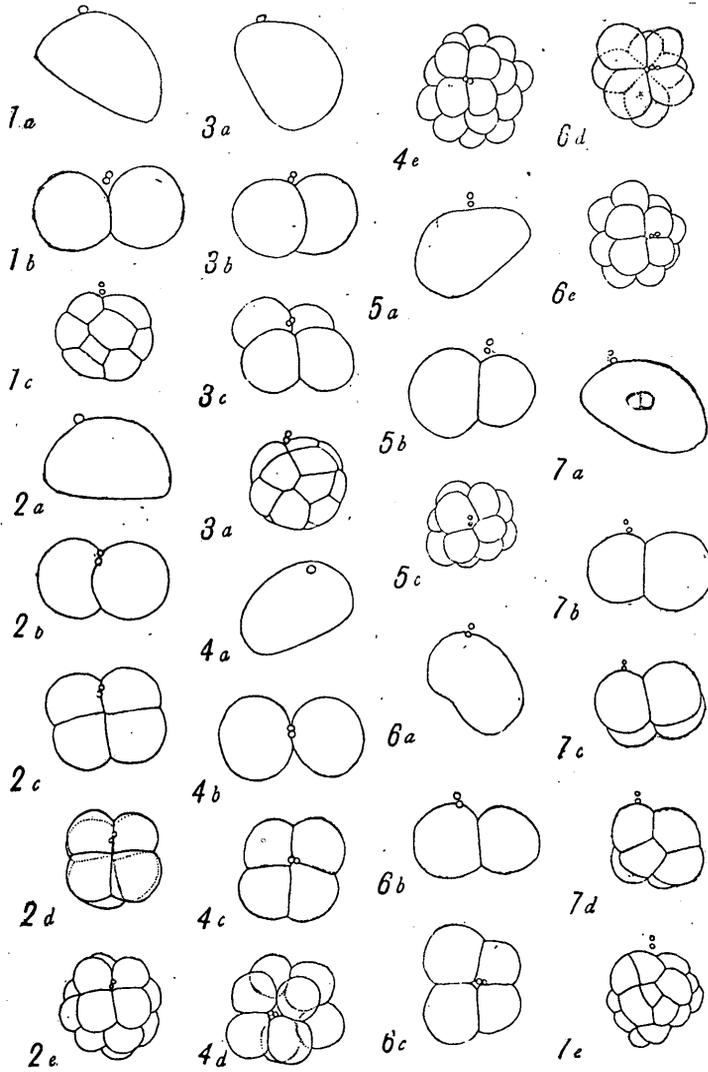


FIG. I. (*Cerëbratulus lacteus*)

1-7, early cleavage stages of seven eggs operated on at different periods between the formation of the first polocyte and the first cleavage. 1-4, four eggs cut at a stage with only the first polocyte ; 5-7, three eggs cut at a stage with two polocytes.

In comparing the above result with ZELENY'S we still find discordance between them. He made the same experiment upon the egg of *C. marginatus* and found out that in every case there was more or less deviation from the normal mode of cleavage ('04, pp. 302 and 306). It may, therefore, be concluded that in the Neapolitan species the cleavage factor is established much earlier than in *C. lacteus*.

As I have already referred to in my previous paper ('08), the above experiment clearly shows that the spindle may be moved about in the egg to its definite position before the karyokinesis reaches the telophase or perhaps the late anaphase, when the diastem is formed. As to the fixation of the position of the spindle, the importance of diastem formation cannot be too much overestimated. It should here be remarked that the establishment of the diastem and that of the cleavage factor are not one and the same thing, but the former is evidently a result of the latter.

II. Experiment B (*C. lacteus*).

A portion of cytoplasm was cut off along different planes from one of the blastomeres¹ before the completion of the first cleavage, care being taken not to injure or remove the nucleus. I have ten cases to report. All divided unequally from the beginning, and the subsequent cleavage was irregular. Two out of ten, however, cleaved fairly normally owing probably to the fact that the injury was not great enough to cause a considerable disturbance of the cleavage factors.

¹ Strictly speaking, the term blastomere should not be employed before the completion of first cleavage, yet the meaning here will be quite clear.

III. Experiment C (*C. lacteus*).

A portion of cytoplasm is removed by a single cut from both the blastomeres during the first cleavage. Six eggs were thus operated on. All divided irregularly excepting two, which deviated a little from the normal mode as shown in Fig. 8a-c. This may be due to the fact that the sections were horizontal or nearly so in either case.

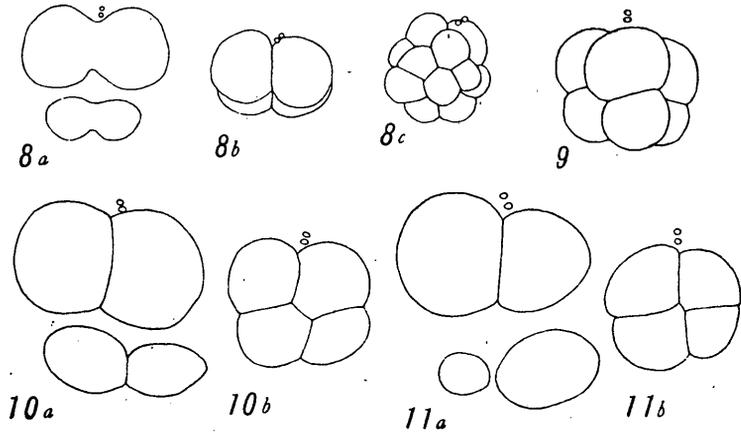
IV. Experiment D (*C. lacteus*).

Close to the end of the first cleavage, when the two blastomeres were still connected by a narrow bridge, the cells were separated from each other by a vertical cut and the cleavage of each blastomere was studied. Sixteen cases were examined and it was found that every one of them performed a partial cleavage exactly like the isolated blastomeres of the 2-cell stage. Some gave rise to closed blastulas, others to open ones. This result confirms ZELENY'S observation made on the egg of *C. marginatus* ('04, pp. 308, 309, 322).

V. Experiment E (*C. lacteus*).

At the 2-cell stage a portion of cytoplasm was cut off from the vegetal region by a horizontal or oblique section, and at the 8-cell stage the size of the upper (the first quartet) and the lower blastomeres were compared.¹ Nine eggs were thus operated on, and it was found that in every case, irrespective of the angle of

¹ This experiment was carried out at the Harpswell Laboratory in the summer of 1907, suggested by a similar experiment which had been performed upon the egg of *Beroë* nearly a year before at Naples.

FIG. II. (*Cerebratulus lacteus*)

8, early cleavage stages of the egg from which the vegetal region was cut off at the beginning of the first cleavage; 9, 8-cell stage of a normal egg, showing the size-relation between the upper and the lower cells; 10a, egg cut horizontally at the 2-cell stage; 10b, same at the 8-cell stage; 11a, another egg cut obliquely; 11b, same at the 8-cell stage. Notice that in both Figs. 10b and 11b the upper cells are somewhat larger than the lower.

section, the proportion of the upper and the lower cells was normal or approximately so, that is, the upper blastomeres were a little larger than the lower. Fig. 10a represents an egg cut almost horizontally. If one compares the 8-cell stage of this egg (Fig. 10b) with that of an unoperated egg, he will at once recognize that the normal proportion is retained. The same phenomenon will be seen in the case of an egg obliquely sectioned (Fig. 11a and b).

It is quite probable, though as yet not experimentally demonstrated, that if the operation be performed immediately prior to the third cleavage, the proportion between the upper and the lower cells would be disturbed, inferring from the results of Experiment A.

VI. Experiment F (*C. lacteus*).

A series of pressure experiments was carried on with regard to the localization problem. Incidentally I noticed a definite modification in the cleavage of compressed eggs.

When undivided egg is subjected to pressure between two planes parallel to its vertical axis, the first cleavage plane passes through the animal pole and always perpendicularly to the pressure. The second cleavage plane is equatorial as MORGAN observed in *Arbacia* ('93, p. 148), giving rise to four cells of *equal size*.¹ The plane is, therefore, parallel to, but a little higher than, the third cleavage plane of the uncompressed egg. If the pressure is relieved from such eggs, the third cleavage takes place vertically, exactly like the second of the ordinary egg. The subsequent history of such eggs does not show any deviation from the normal cleavage.

It is hardly necessary to state that, if the egg remains for some time under a moderate pressure, the third cleavage planes appear parallel to the first as has already been observed in compressed eggs of other forms, giving rise to eight cells arranged in one plane.

VII. Experiment G (*C. lacteus* and *C. marginatus*)².

Eggs were fertilized artificially as in other experiments. The moment the first cleavage constriction was to appear, they were shaken so as to remove their membrane and were transferred³ into Ca-free

1 In passing it may be pointed out that C. B. WILSON ('00) seems to have made his observation on the compressed eggs of *C. lacteus*, judging from his figure (Pl. 10, Fig. 52) and statements that the second cleavage is horizontal and the third vertical (pp. 146-147).

2 This experiment was carried out primarily for some other purpose in the summer of 1904 and was repeated with the same result in the spring of 1906.

3 It was not easy to transfer eggs alone into Ca-free seawater; always a little ordinary seawater went in with the egg. In this experiment, they were, as a matter of fact, kept in the seawater with diminished amount of calcium. I mention this expressly because in using pure Ca-free seawater the result may be different.

seawater. Their early cleavage stages were studied in the water.

The eggs examined for this experiment were not dispermic, as shown by the fact that the first two cleavages were not simultaneous. The blastomeres did not press together, but remained almost spherical (Fig. 12), as is always the case with eggs under the same treatment. It is interesting to note that the subsequent history is exactly alike to the type of dispermic eggs, which cleave into four cells at once ("Simultanvierer" of "ebener Tetrastertypus") as first observed by FOL and later studied by DRIESCH ('92, p. 31, figs. 69, 70), MORGAN ('95, p. 73), BOVERI ('07, pp. 11-12) and others. The third cleavage planes are vertical instead of horizontal, giving rise to eight blastomeres¹ arranged in a ring (Fig. 15) or less frequently in two rows as in the egg of *Beroë* (Fig. 14). One cannot hesitate to correlate the horizontal position of the third division spindle with the failure of the pressing together of the four blastomeres at the end of the second cleavage, but at the same time this experiment does not exclude the possibility that this is due to the shaking (*cf.* MORGAN '95, BOVERI '07). But the cause of the abnormal appearance of the third cleavage does not concern us here. What has a direct bearing upon the present problem is the further history of such eggs. The fourth cleavage is horizontal, resulting, as in the third division of the normal egg, in eight upper larger and eight lower smaller blastomeres (Figs. 16 and 19). The fifth cleavage takes place exactly like the fourth of the normal egg; *i. e.*, the division of the first quartet cells and the formation of the second quartet (Fig. 18). So far as my observation went, each blastomere of the 8-cell stage behaved like that of the 4-cell stage of the normal egg.

¹ That the blastomeres isolated at the 4-cell stage do not divide vertically, may be due to the fact that the position of cleavage centres was already settled at the time of the operation.

VIII. Early Cleavage Stages of Trefoil Eggs
(*C. lacteus* and *C. marginatus*).

Trefoil eggs¹ (Fig. 19) were isolated from the normal eggs, and their mode of cleavage was studied singly. This observation was made first in 1904 and was repeated both in 1905 and 1906.

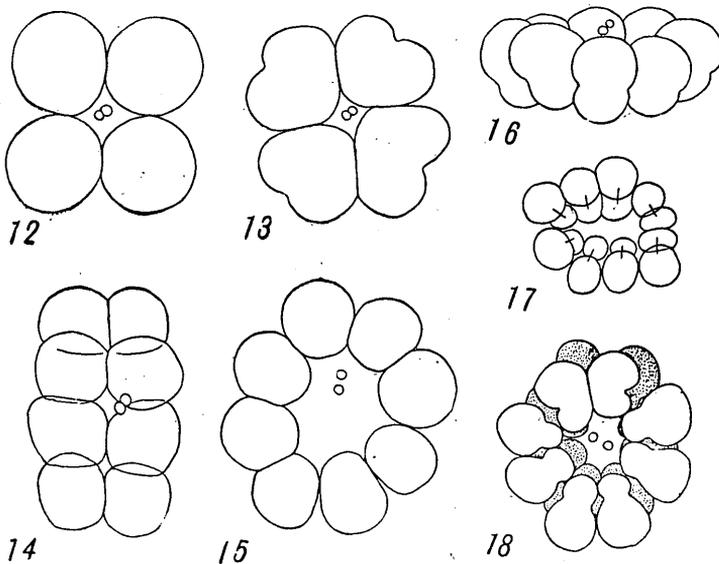


FIG. III. (*Cerebratulus marginatus* 12-16, 18; *C. lacteus* 17).

12-18, early cleavage stages of the eggs treated with Ca-free sea-water. 12, 4-cell stage; 13, beginning of the third cleavage; 14, 8-cell stage, with blastomeres arranged in two rows; 15, 8-cell stage, with blastomeres arranged in a ring; 16, beginning of the fourth cleavage; 17, 16-cell stage; 18, a stage preceding the 32-cell stage, seen from the vegetal pole. Upper cells are stippled.

¹ Trefoil egg = "Simultandreier." It may be mentioned that there are two kinds of trefoil eggs: (a) the one due to three vertical planes, and (b) the other due to one vertical and two transverse cleavage planes. These two cases can be very readily distinguished by the position of polar bodies. In this section the former kind alone is meant by trefoil egg, since the latter is of little value for the present purpose. The "Simultanvierer" is very seldom met with in *Cerebratulus*.

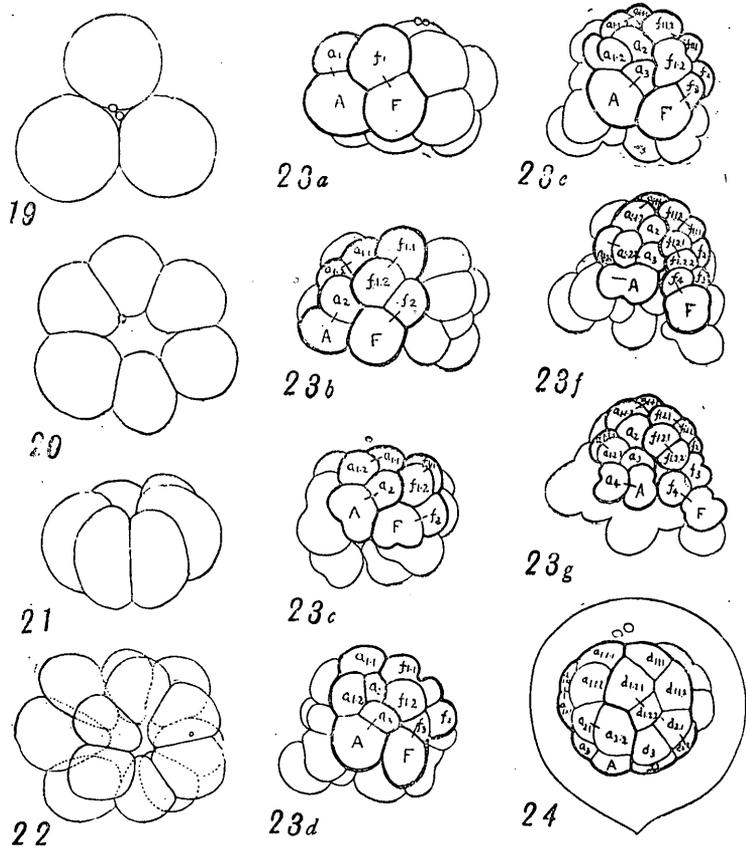


FIG. IV. (*Cerebratulus marginatus* 14-23; *C. lacteus* 24).

19-23, early cleavage stages of trefoil eggs. 19, trefoil egg at the end of the first cleavage; 20, 6-cell stage seen from the vegetal pole; 21, 6-cell stage in profile; 22, 12-cell stage; 23a-g, seven stages of a trefoil egg (12-42-cell stage). The heavy lines separate the blastomeres of two sextants; 24, 32-cell stage of a normal egg.

The trefoil egg cleaves like that of echinoderms described by MORGAN ('95, p. 73) and BOVERI ('07, p. 25). The second cleavage is vertical resulting in a 6-cell stage (Figs. 20 and 21). The third cleavage is horizontal as in the normal egg (Figs. 22 and 23a). The subsequent cleavage (Fig. 23 b-g) shows clearly that each blastomere of the 6-cell stage behave like that of the 4 cell-stage

of the normal egg (*cf.* Fig. 24). The blastulas are often open at the vegetal pole.¹

From what has been described in the foregoing and this section, we arrive at a conclusion of considerable interest that whatever the number of initial blastomeres (four in the normal egg, six in the trefoil egg and eight in the Ca-free sea-water egg) the mode of cleavage of each remains unaltered. Further detailed study of the cytogeny of multiple cleavage is very desirable, for instance, with a regard to the teloblast formation. CONKLIN ('07) has made similar observation in the egg of *Crepidula plana*. He compressed the egg and found that the third cleavage may divide one or more of the macromeres equally, thus giving rise to five, six or eight macromeres. If the pressure is removed from such eggs, each macromere gives rise to micromeres in a manner approximately normal. From this he concludes that the number of micromeres depends upon the number of macromeres and that the omission or the addition of cleavage does not alter the character of localization which determines the character of cleavage. As regards the significance of this phenomenon I shall speak later.

IX. Summary.

The results obtained from the experiments upon the egg of *Cerebratulus lacteus* are as follows:

1. The mode of cleavage is not disturbed by the removal of a portion of cytoplasm, unless the operation is performed close to the beginning of the first cleavage.

¹ In the figures referred to, one notices that the third quartet was given off dextrorotically as in the second. But this, I think, may be taken for an exceptional case.

2. If a portion of cytoplasm, whether from one or two blastomeres, is removed during the first cleavage, the mode of cleavage is disturbed. Slight injury or horizontal cut affects the cleavage but little.

3. If the blastomeres are separated by a vertical cut near the end of the first cleavage, partial cleavage takes place as in the blastomeres isolated at the 2-cell stage.

4. If a portion of cytoplasm is cut off from the vegetal region at the 2-cell stage, the size-relation of the upper and lower cells of the 8-cell stage is normal, irrespective of the angle of the section.

5. In the egg compressed between two planes parallel to the main axis of the egg, the second cleavage is equatorial ; and upon relieving the pressure, the third cleavage is vertical and perpendicular to the first.

The following results were obtained from the study of the egg of both *Cerebratulus lacteus* and *C. marginatus*.

6. In the eggs kept in Ca-free sea-water, the third cleavage is vertical resulting in eight blastomeres arranged either in a ring or in two parallel rows.

7. In the trefoil egg the second cleavage is vertical, giving rise to six blastomeres arranged in a ring.

8. Irrespective of the number of the initial blastomeres (basal cells) formed by vertical cleavages, the division goes on normally in each of them.

X. General Discussion.

The results of the foregoing eight series of experiments, if considered with those of other investigators obtained from the egg of nemertine and other forms, seem to throw some light on

the fundamental problem of cleavage-physiology. In the following pages I shall briefly deal with the relation between cleavage pattern and "egg-organization" and the nature of cleavage factors viewed in the light of recent experimental studies and especially of the results described in the present paper.

In order to get at the cause of cleavage pattern we must first look into the present status of the question of germinal localization. Detailed discussion on this subject, however, will be deferred until some other opportunity.

The idea of germinal localization in the egg was, as is well known, a logical extension of the organ-forming regions in the blastoderm of the chick to the one-cell stage (His, '74 p. 19). This hypothesis soon gained ground from indirect evidence obtained from various experiments upon the egg of ctenophore, frog, etc., and the conclusion was reached that there must be some invisible localization of specialized materials in addition to the promorphology of the egg. Meanwhile forms were found, in which the egg has a definite visible granular localization, such as *Myzostoma*, *Patella*, *Dentalium*, Ascidians. In the egg of *Strongylocentrotus* (*Paracentrotus*) a pigment belt was discovered, which was supposed to correspond in some way or other to the internal zonal arrangement of specialized materials. Then it came to be thought that the visible localization of granules, if present, is identical, or approximately so, with the supposed germinal localization.

This conclusion was refuted by some authors on the ground that the variation in the granular localization does not show corresponding difference in the morphogeny, for instance, by LILLIE for *Unio* ('01, p. 262) and by ZUR STRASSEN for *Ascaris* ('06, p. 56). GARBOWSKI found that the pigment ring around the egg of *Strongylocentrotus* may take various angles to the embryo axis ('05, p. 603).

The body of direct evidence recently acquired by centrifuging method is growing rapidly to prove that granular localization does not have so close a relation to morphogenic factors as we have thought. And beyond all doubt it was established that visible granular localization is not what we have termed germinal localization (*cf.* LILLIE '09, CONKLIN '09, MORGAN '08 and '09). Centrifuging method has certainly brought experimental embryology into a new phase. It may be remarked, however, that the new evidence does not invalidate the idea of germinal localization, but it carries this hypothesis nearer to its original form. Taking into consideration all the experimental evidence hitherto accumulated, we can not but think that there is, independent of granular localization, a definite arrangement of specified material (ground substance) that is closely connected with morphogenic process (germinal localization). But how complicated this structural arrangement is, is the point which begs further investigation. At any rate we may conveniently conceive three systems superimposed one upon another, *viz.*, promorphology, germinal localization and granular localization. The first two may roughly correspond to what Driesch calls "Intimbau" or "Intimstruktur" and the last to his "Stoffbau." Leaving the matter of egg-organization at this stage, let us consider the relation between cleavage pattern and each of these systems.

It has often been remarked that granular localization and cleavage pattern stand in close relation to each other. This seems true especially in such forms, in which the oöplasmic movements can readily be seen (CONKLIN '99, '02). But the recent centrifuging method has successfully proved that this relation is of secondary importance in at least seven forms, *viz.*, *Arbacia*, *Chaetopterus*, *Nereis*, *Cumingia*, *Hydatina*, *Cynthia*, and *Crepidula*. Here, whether or

not the primary egg-axis corresponds to the secondary axis induced by centrifugal force does not concern us. Besides experimental evidence we have a few observations showing that cleavage goes on normally irrespective of the variation in the distribution of yolk granules (LILLIE '01, ZUR STRASSEN '06). In all probability, therefore, it is safe to conclude that the cleavage pattern is not governed by granular localization.

It is hardly necessary to state that cleavage pattern is intimately related with germinal localization. Yet these two are sometimes found dissociated, as we see in the egg of *Cerebratulus*, in which, at a period when the morphogenic factors are already established (YATSU '04), the factors of cleavage pattern are not yet fixed as we have seen in Exp. A. In the sea-urchin egg the cleavage factors seem to establish themselves in one-cell stage, when the morphogenic factors are still rather vague (DRIESCH '96, Appendix I, pp. 104-112). In *Dentalium* WILSON ('04, pp. 42, 43, 66, 67) found that despite the removal of a portion of the polar lobe material, the polar lobe of normal proportion is formed. ZIEGLER ('98) and myself¹ have made during subsequent cleavages experiments on the egg of *Beroë* with the results that from which the vegetal region has been removed, micromeres are formed in normal size-relation in eggs. An interesting observation was made by LILLIE ('09, pp. 63, 64) on the egg of *Chaetopterus*, that nucleated fragments freed of yolk granules by centrifuging the egg, divide unequally into two cells of normal proportion. Lastly in *Cerebratulus*, as described under Exp. E, the proportion between the upper and lower cells of the 8-cell stage is normal even in the egg, from which a portion of vegetal region

¹ The results are still unpublished.

had been removed at the 2-cell stage (pp. 5, 6). The above examples tend to show, if I mistake not, that the germinal localization and cleavage factors are not so closely related as we have thought.

As regards the relation between promorphology and cleavage pattern it cannot be doubted, as almost all investigators agree, that there is a direct connection. It may here be added that what I have stated under sections VIII and IX seems to indicate the importance of the polarity in relation to cleavage pattern: the cleavage goes on normally in all blastomeres¹ (4, 6 or 8 in number) that have arisen by vertical cleavage.

Now as to the cleavage factors. The regular cleavage pattern is the result of a regular succession of internal stimuli, which determine the position of the spindle and consequently the relative size of the blastomeres. The factor of directing cleavage planes manifests itself quite early, for instance, by the position of the cleavage centres and in *Ascaris* still earlier by the "horns" or portions of chromosomes projected from the nucleus, as noticed by ZUR STRASSEN ('06, p. 134). The factor controlling the position of the spindle, on the contrary, seems to come into effect much later than that of direction. The spindle may move about in the blastomeres like a boat carried to and fro by the waves, when the normal relation is disturbed by the removal of a certain portion of the cytoplasm. As we have already seen (see pp. 2, 6, 12), we have good reason to believe that there is no predetermined protoplasmic differentiation for future diastems in the egg. ZUR STRASSEN ('06, p. 145) suggests, with some reserve, that in the egg of *Ascaris* the position of the spindle may be determined by preexisting

¹ One may argue that this is simply due to similar distribution of materials in each blastomere. That may be so in both sea-urchin and *Cerebratulus* but certainly not in *Crepidula*,

protoplasmic differentiation and also that the cleavage plane of certain cells may be transmitted to their progeny. It is extremely difficult to assume such predetermined cleavage planes in the egg of *Cerebratulus* as already mentioned and still more so in that of *Crepidula*, in which vivid protoplasmic movements can be seen.

In understanding the factors controlling the position of the spindle, one should not overlook another important one emphasized especially by LILLIE ('99, '01), *viz.*, adaptation in cleavage. Though the cleavage pattern may be artificially altered without causing any morphogenetic disturbances, yet it cannot be doubted that each division under normal condition has prospective significance. Moreover we must take into consideration that modifications in cleavage have taken place during the vast length of phylogeny, rendering a mechanical explanation of the present mode almost impossible. At the outset some of the processes might have had a mechanical significance, but now they are incorporated into what we might call inherent or "active physiological" (ZUR STRASSEN) property of the egg. We may find an analogous case in the *Bombinator* tadpole, in which at first the perforation of the operculum was in all probability due to the mechanical stimuli of growing arms beneath, but at present takes place without them (BRAUS '06).

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Literature.

- BOVERI, T., '07.—Die Entwicklung dispermer Seeigel-Eier. Ein Beitrag zur Befruchtungslehre und zur Theorie des Kerns: *Zellen Studien*. Heft 6.
- BRAUS, H., '06.—Vordere Extremität und Operculum bei *Bombinator*: *Morph. Jahrb.* 35.
- CONKLIN, E. G., '99.—Protoplasmic movement as a factor in differentiation: *Wood's Holl Biol. Lectures* 1898.
- „ '02.—Karyokinesis and cytokinesis in the maturation, fertilization and cleavage of *Crepidula* and other gasteropoda: *Journ. Acad. Nat. Sc., Phil., II Ser.* 12.
- „ '07.—Experimental studies on nuclear and cell-division: *Proceed. Soc. Exp. Biol. and Med.* 4.
- „ '09.—Organization and early development of the eggs: *Anat. Rec.* 3.
- DRIESCH, H., '92.—Entwicklungsmechanische Studien V., Von der Furchung doppelbefruchteter Eier: *Z. w. Z.* 55.
- „ '96.—Betrachtungen über die Organisation des Eies und ihre Genese: *Arch. Entw.* 4.
- GARBOWSKI, T., '05.—Über die Polarität des Seeigeleies: *Bull. d. l'Acad. des Sciences de Cracovie*. 1905. 8.
- HIS, W., '74.—Unsere Körperform und das physiologische Problem ihrer Entstehung.
- LILLIE, F. R., '99.—Adaptation in cleavage: *Wood's Holl Biol. Lectures* 1898.
- „ '01.—The organization of the egg of *Unio*, based on the study of its maturation, fertilization and cleavage: *Journ. Morph.* 17.
- „ '09.—Polarity and bilaterality of the annelid egg. Experiments with centrifugal force: *Biol. Bull.* 16.
- MORGAN, T. H., '93.—Experimental studies on echinoderm eggs: *Anat. Anz.* 1893.
- „ '95.—A study of variation in cleavage: *Arch. Entw.* 2.
- „ '08.—The localization of embryo-forming regions in the egg: *Science* 28.
- „ '09.—The effects produced by centrifuging eggs before and during development: *Anat. Rec.* 3.

- MORGAN, T. H., and LYON, E. P., '07.—The relation of the substances of the egg, separated by a strong centrifugal force, to the location of the embryo: Arch. Entm. 24.
- WILSON, C. B., '00.—The habit and early development of *Cerebratulus lacteus*: Quart. Journ. 43.
- WILSON, E. B., '03.—Experiments on cleavage and localization in the nemertine egg: Arch. Entm. 14.
- „ '04.—Experimental studies on germinal localization. I. The germregions in the egg of *Dentalium*: Journ. Exp. Zool. 1.
- YATSU, N., '04.—Experiments on the development of egg fragments in *Cerebratulus*: Biol. Bull. 4.
- „ '08.—Some experiments on cell-division in the egg of *Cerebratulus lacteus*: Annot. Zool. Japon. 6.
- ZELENY, C., '04.—Experiments on the localization of developmental factors in the nemertine egg: Journ. Exp. Zool. 1.
- ZIEGLER, H. E., '98 —Experimentelle Studien über die Zelltheilung (Fortsetzung) III Die Furchungszellen von *Beroë ovata*: Arch. Entm. 7.
- ZUR STRASSEN, O., '06.—Die Geschichte der T-Riesen von *Ascaris megalocéphala* als Grundlage zu einer Entwicklungsmechanik dieser Species: Zoologica. 17.