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Anatomy. — “*On the relation of the first three cleavage planes to the principal axes in the embryo of Rana fusca Rösel.*” By Dr. H. C. DELSMAN. (Communicated by Prof. VOSMAER).

(Communicated in the meeting of May 27, 1916).

In this paper the results are given of some pricking experiments on the eggs of *Rana temporaria*, which I hope may contribute to the solution of various questions about which unanimity of opinion has as yet not been attained in spite of the numerous investigations on the earliest development of the amphibian egg.

Starting point was the question: what becomes of the animal pole of the egg? It seemed very important to obtain an answer to this question in regard to a theory, worked out by me some years ago, on the evolution of the vertebrates from invertebrates (1913, a, b). The first principle on which this theory is based is that the invertebrate ancestor of the vertebrates must be sought among the Annelida, a suggestion which was upheld already half a century ago by DOHREN, SEMPER and by many others afterwards, and that the transition must be conceived to be such that the stomodaeum of the Annelida became the medullary canal of the Chordata. Since this last supposition is bold enough to endanger in some quarters the reputation of him who dares to put it forth (which I felt from the beginning), it was with great satisfaction that I found that nobody less than the discoverer of the neurenteric canal, KOWALEWSKY, in 1877 already had suggested a similar explanation, although less sharply formulated, when he wrote in a discussion on the homology of the nervous system in worms and chordates: “Die sonderbare Bildung des Nervensystems bei den Embryonen vieler Wirbelthiere (Amphioxus, Amphibien, Störe, Plagiostomen), bei denen Darm- und Nervenrohr ein zusammenhängendes Rohr darstellen, lässt uns vermuthen, dass vielleicht solche Thierformen existirten oder auch existiren, welche ein dem Nervenrohr der Wirbelthiere homologes Rohr besitzen, obgleich dasselbe eine andere Function erfüllt, dass es z.B. ein Theil des Darmcanals sei”.

The second idea underlying the theory proposed by me is that, whereas in *Amphioxus* the whole of the medullary canal must be regarded as homologous with the stomodaeum of the Annelida, in the Craniota the praechordal part of the cerebral plate must be considered as having originated from the so-called apical plate of the annelid larva, the trochophora, by annexation of this latter by the medullary canal. Without enlarging upon the different

arguments adduced by me for this second supposition, I here only will mention that formerly already I pointed out the possibility to prove or verify it by experiment. For in the centre of the apical plate the animal pole of the egg is found, characterised by the fact that there the extrusion of the polar bodies took place and the two first cleavage furrows crossed each other. A similar relation may now be expected to exist between the cerebral plate and the animal pole in the vertebrates, where the history of the animal pole cannot be traced with equal certainty, since the polar bodies do not stay there and the cleavage is not of such a kind that a definite point can be kept in view. Pricking experiments should bring certainty here.

If the cerebral plate of the Craniota is really homologous with the apical plate of the annelid (and mollusc) larva, it may be expected that we shall find back the animal pole on the cerebral plate. On closer examination it appears that this conclusion formerly drawn by me (1913 b) cannot be strictly correct. For a glance at the schemes then given of the structure of annelid, amphioxus and craniote shows at once that in the latter not only the cerebral plate must be furnished by the apical plate, but also, just as in the former two, the ectoderm covering the prostomium. Hence the cerebral plate can only originate from part of the apical plate and moreover this part must, according to the scheme mentioned, be the half of the top-plate contiguous to the stomodaeum (in casu the medullary canal), which consequently is the oral half in the Annelida, but the aboral half in the Chordata, where the old mouth loses its function and a new one breaks through at the opposite side. The other half then furnishes the ectoderm of the prostomium, not only ventrally, but also — the ectoderm cells during the closing of the cerebral plate evidently being shoved upwards on either side — dorsally, over the cerebrum. Now if the cerebral plate can be formed only from the posterior half of the apical plate, from the part where also with Annelids and Molluscs the rudiment of cerebral ganglia and eyes is found, it may be expected that the animal pole will be found back not so much on the cerebral plate as either on or just in front of its anterior border, i. e. on the transverse head-fold. A glance at the three above-mentioned schemes given by me shows plainly that there is every reason to expect the animal pole at the level of the neuropore of the Craniota. To prove this experimentally would not only afford a verification of my theory, which reached this conclusion by a quite different train of reasoning, but would compel also those who attach little value to such theories on the

ground that it is so long ago since the Vertebrata originated and nobody has witnessed the event and who would therefore be glad to see anatomy and embryology revert to the mere accumulation of facts without feeling any need for thoughts, to acknowledge that such a theory can occasionally lead to some good, as here to the statement of a new "fact": the relation between the animal pole and the cerebral plate in the Craniota.

The frog eggs were placed in a small glass-scale with water and cotton wool when in the 4- or 8-celled stage, after having been freed from the surrounding jelly and under weak microscopical enlargement were pricked with the point of the spine of a hedge-hog, in such a way however that only a very trifling wound was made, which requires a fair amount of practice and patience. For at a somewhat more serious lesion a considerable extraovate is at once protruded, the size of which still increases during the subsequent cleavage and which results in abnormal development. For this reason similar experiments undertaken last year did not yield a single reliable result and made me doubt, as SCHULTZE (1889) and H. V. WILSON (1900) did, of the value of pricking experiments like these. But this year I had better luck. To be sure such trifling wounds have the disadvantage that often they soon heal entirely and that the scab which is formed is cast off, but the development is not interfered with in the least, the egg remains movable within the egg capsule and consequently can assume the position of equilibrium corresponding to each developmental stage. The results turned out to be very satisfactory, although occasionally eggs had to be rejected in which the mark was cast off too early.

With eggs that had been pricked on the animal pole in the 4- or 8-celled stage and during gastrulation had been repeatedly sketched by means of the drawing-apparatus, so that more or less complete series were obtained, I finally found the mark just in front of the anterior border of the cerebral plate. In four eggs I could follow the process so far without accidents such as the coming off of the marks and in all these four cases the same result was obtained. Elsewhere I hope to give reproductions of some of these series.

This result is fully in accordance with what might be expected on my theory. But it does not stand alone. With other amphibian species, particularly with the American frog *Acris* and the axolotl (*Amblystoma*), EYCLESHYMER made the same experiment as early as 1895 and 1898 and in both these forms obtained exactly the same result. The mark here was found back either just in front of or upon or just behind the transverse head-fold. Not only in

Amphibia, however, but also in Teleostei, where the earliest development differs in so many respects from that of the Amphibia, it may be taken for granted that the animal pole afterwards exactly indicates the anterior end of the embryo. When in 1913 I tried to show that in the anchovy the cerebral plate occupies nearly the same place as the animal pole, I overlooked a paper in which SUMNER (1904) describes pricking experiments on teleostean eggs, particularly those of some North-American species of *Fundulus*. When he pricked in the centre of the still small germinal disc which later extends concentrically over the whole egg, this mark was also found back exactly in front of the foremost point of the rudiment of the embryo. This points to a general prevalence of such a relation between the animal pole and the cerebral plate in Craniota. Nevertheless it should be mentioned here that HELEN DEAN KING (1902) in *Bufo* and EYLESHYMER (1902) in *Necturus* concluded from similar pricking experiments that in these the animal pole is found some distance in front of the transverse head-fold and that the latter even lies halfway between animal pole and egg equator. However it seems to me that these last experiments are not so conclusive that they would preclude the possibility that on closer examination these forms also might turn out to conform to the rule. Further investigations on this point are wanted.

Besides the animal pole I marked in the 8-celled stage other crossing points of cleavage lines, especially the four intersections of the equatorial cleavage groove, which, as appears from fig. 1, lies at a considerable distance above the equator of the egg, and the two meridional grooves. We shall indicate these points by *b*, *c* and *d*, *b* lying on the side where the white area of the lower portion of the egg reaches farthest upwards and which must be denoted as the dorsal side. On the opposite ventral side *c* will lie, *d* denoting the two lateral crossing points. I did not succeed in marking also the vegetative pole without being troubled at once by a considerable extraovate. Each egg always had only one single mark. Although on some eggs marks were made in two or even three of the just-mentioned spots I am sorry I could pursue none of these eggs as far as the appearance of the medullary plate without all the marks, or all except one, coming off. Such eggs were always chosen which in the eight-celled stage presented the most regular appearance, without large "cross-lines" ("Brechungsfurchen") in the points of intersection and in which the highest point of the white area was exactly cut by one of the two meridional cleavage planes, so that it might be assumed that the first cleavage plane coincided with the

meridional plane of the fertilised egg. This point will be dealt with later.

By sketching the marked eggs from time to time with the drawing-prism I obtained several series, which may e.g. give exact information on the appearance and displacement of the blastoporic rim. On this point the most divergent opinions until the present day are met with among different investigators.

The oldest view is that the black hemisphere becomes the dorsal part of the embryo, so that the egg axis lies dorso-ventrally. As is well known PFLÜGER (1883) first pointed out that the blastopore moves forward over more than 90° from the point where the dorsal lip first appears, from which PFLÜGER concluded that the foundation of the nervous system originates on the white hemisphere. He added however emphatically: "Um nicht missverstanden zu werden, möchte ich hervorheben, wie ich keineswegs bewiesen zu haben glaube, dass die ganze Uranlage des centralen Nervensystems ein Derivat der weissen Hemisphäre des Eies sei . . . so bleibt es denkbar, dass die vorderen Teile der Markanlage, die dem Gehirn und möglicherweise sogar dem oberen Teil des Rückenmarks entsprechen, sich in der schwarzen Hemisphäre bilden".

The controversy between ROUX (1888) and SCHULTZE (1887) is well known, the former of whom let the dorsal lip of the blastopore move over the white half of the egg through no less than $170-180^\circ$, so that the medullary canal consequently originated entirely on the white half, while SCHULTZE on the other hand declared all displacement of the blastopore border to be illusory and ascribed it to a rotation of the egg, so that it would just be on the black hemisphere that the medullary canal originates. Only on this point they agreed, but as we shall see, erroneously, that the egg axis afterwards has a dorsoventral direction. The place where the dorsal lip is first noticed is according to ROUX the rostral, according to SCHULTZE the caudal end of the embryo. BERTACCHINI (1899) and HERTWIG (1902) took the side of ROUX, LWORF (1894) that of SCHULTZE. Among later-investigators however, the opinion begins to prevail, that neither of the two conceptions mentioned is correct, but that the embryo is formed partly on the white, partly on the black hemisphere and that consequently the egg axis is not perpendicular to the longitudinal axis of the embryo but has more or less the same direction. This view was first put forth by ASSHETON (1895) and after him by KORSCH (1900), according to whom the egg axis lies in the embryo from a ventral point in front to a dorsal point behind. If SCHULTZE was of opinion that the formative material of the embryo lies entirely in front

of the dorsal blastopore border and ROUX, HERTWIG, BERTACCHINI that at first it surrounds the blastopore as a ring, according to KOPSCH there is some truth in both statements, the rudiment of the head being found in front of the newly formed blastopore lip, the contiguous rudiment of the dorsal parts of the trunk lying round the blastopore border in the semilunar stage. This last view is more and more accepted by later investigators (H. V. WILSON, 1900, 1902, KING, 1902, IKEDA, 1902) and also my experiments confirm it entirely, as will be shown. Moreover this result is in complete accordance with what might be expected on my theory. The view is gaining acceptance that the principal axis of the egg and the longitudinal axis of the embryo approximately coincide and that consequently, when the first cleavage of the egg separates the left and right halves of the embryo (which is so in the majority of cases, see later), the second cleavage will not separate rostral and caudal, but dorsal and ventral parts of the embryo. Meanwhile opinions still differ very much; thus BRACHET (1902, 1905) recently has maintained the view that the transverse headfold originates exactly in front of the spot where the blastoporic rim first appears, i.e. about the egg equator (ROUX's view), that consequently the embryo will lie entirely on the lower hemisphere of the egg, but that the caudal end does not, as ROUX thinks, extend on the other side as far as the equator, but no farther than just beyond the vegetative pole. The egg axis "n'est en relation avec aucun des axes principaux de l'embryon" (1905).

About the place where the dorsal lip first appears and about the extent of its progression over the surface of the egg, opinions are also rather divergent as yet. PFLÜGER and ROUX see the dorsal blastopore lip originate on the egg equator, PFLÜGER lets it travel a distance of a little over 90° , ROUX of $170-180^\circ$, MORGAN and UME TSUDA (1884) see it originate $\pm 30^\circ$ below the equator and travel 120° . ASSHETON (1894) and KOPSCH (1900), with whom IKEDA (1902) in the main agrees, also let it appear a little below the equator (according to KOPSCH on an average 25°) and move through a distance of $60-70^\circ$ (ASSHETON) to 75° (KOPSCH). BERTACCHINI (1899) again quite agrees with ROUX and estimate the distance travelled through a little under 180° . KING (1902) finds in *Bufo* a displacement of 140° from a point below the equator. EYLESHYMER gives no definite data on this point, his opinion would probably be in fair accordance with the results obtained by me.

By carefully watching the marked eggs and by drawing them repeatedly the above questions of course can be answered with certainty. The results of my experiments for *Rana fusca* I have

combined in a single figure, obtained by the combination of many other figures, two drawings being each time superposed and held up to the light, the details of one figure being in this way transferred to the other.

The eggs marked at the animal pole teach us what follows :

The dorsal blastoporic lip is formed very little below the equator (much less than 25° or 30° , see above) and immediately begins to grow over towards the vegetative side. The ventral blastopore lip is formed about diametrically opposite the animal pole,

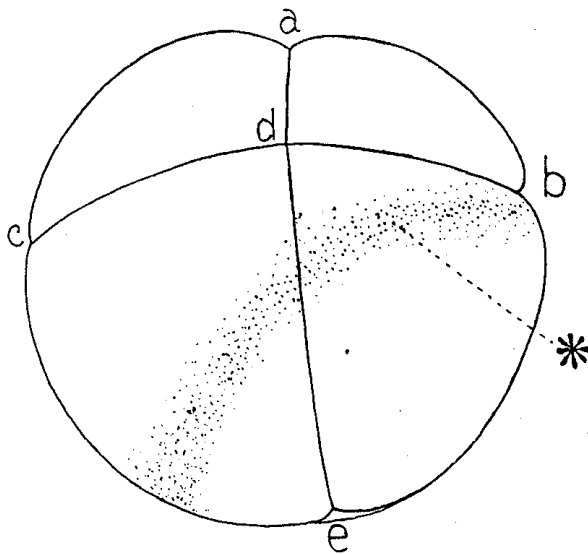


Fig. 1. Eight-celled stage seen laterally.
* confine between light and dark area.

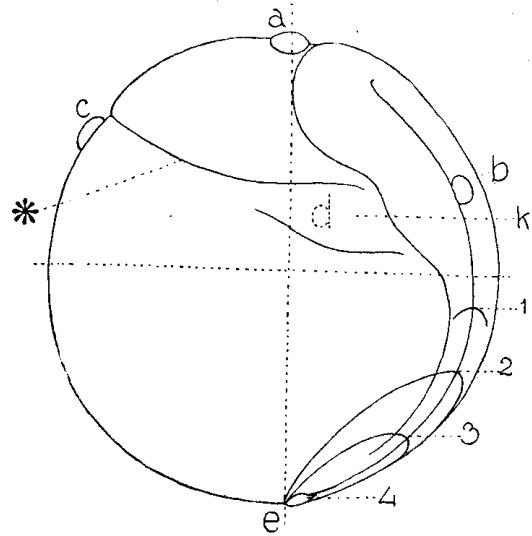


Fig. 2. Representation of the situation of the marks *a*, *b*, and *c* at the time of the appearance of the medullary plate and of the closing of the blastopore.

k. Rudiment of the gills.

1, 2, 3, 4 dorsal blastopore lip during the closing.

* edge of the so-called sense-plate.

a little bit more to the dorsal side. This border practically does not move so that the closing of the blastopore finally takes place at this same point. From this ensues that the dorsal blastopore lip progresses through a little less than 90° (estimation not under 80°).

When the blastopore has finally narrowed to a short slit and the medullary folds arise, this slit consequently still lies almost diametrically opposite the animal pole, which is situated exactly in front of the cerebral plate. The distance between the two is, when measured

dorsally, somewhat shorter than when measured ventrally. Hence the length of the dorsal embryonic rudiment is a little less than 180° . Although in yolk-laden eggs this arch has a somewhat smaller length, still the above relation seems to occur regularly in various animal groups. For besides in Amphibia we also find it in Teleostei, especially in those with pelagic eggs not too much yolk-laden it is generally observed that the closure of the blastopore takes place almost diametrically opposite the animal pole, i.e. the point of the nose, so that here also the embryo extends over almost 180° between the animal and vegetative poles. Far from a fundamental difference, as MORGAN (1894) thought, we find a fundamental agreement in the position of the embryo in amphibian and teleostean. Also for Amphioxus the same holds, CERFONTAINE'S (1906) pictures of gastrulas of Amphioxus with the second polar body still attached to it, show that here too the final narrowed blastopore lies approximately diametrically opposite the animal pole, while the dorsal blastopore lip is equally formed here near the egg equator.

We clearly see from fig. 2 that the place of the first appearance of the blastoporic rim lies about halfway the length of the embryo, that consequently the embryo is formed half on the black, half on the white hemisphere, and that the main axis of the egg coincides with the longitudinal axis of the embryo, so that the second cleavage of the egg in so-called typical development (ROUX, see later) separates the dorsal and ventral halves. Since in the 4- or 8-celled stage the distance from the animal to the vegetative pole (upper and lower crossing point of the first two cleavage planes) is also a little shorter when measured dorsally than when measured ventrally (the two ventral cells in stage 4 being somewhat larger than the two dorsal ones), it follows as well that the closure of the blastopore takes place exactly at the vegetative pole.

Let us now consider the eggs marked at *b*, *c*, or *d*, which are the points of intersection on the third or equatorial cleavage furrow. Since the roof of the cleavage cavity is getting continually thinner during the processes of cleavage and gastrulation, one would suppose that here an extension of surface takes place and that consequently the points *b*, *c*, and *d* move away from each other and from the animal pole. To my surprise however I found that, if this be the case, still it is to such a small extent that practically the little marks remain stationary. This wants explaining. It may be e.g. that the volume of the cells decreases by expulsion of liquid into the cleavage cavity, or by consumption of yolk by the cell-division which is particularly active here, or by both causes. Next year I hope to be

able to continue and repeat these experiments, as the number of eggs which in each of the cases reached the medullary plate stage without losing their marks did not exceed three or four. But the results of these agreed so completely that for the present my conclusion is that the marks at *b*, *c*, or *d* are not appreciably displaced.

When the dorsal blastopore lip is formed, the mark at *b* is found lying about equally far in front of it as in stage 8 the point *b* is distant from the egg equator. The more the blastopore lip is then shifted backwards the larger the distance becomes. At last the mark is found on the medullary plate exactly behind the cerebral plate.

The mark at *c* is found back at some distance before the anterior end of the cerebral plate in front of (properly speaking behind) the border of the so-called sense-plate, which lies round the front part of the cerebral plate in the shape of a crescent and the border of which (Fig. 2: *), as further development shows, indicates the border of the head as far as the gill arches. On this plate the two suckers, the mouth and the two olfactory grooves are afterwards found. Behind this plate lie on both sides of the anterior end of the medullary plate (behind the cerebral plate) two little projections (*k*), representing the rudiment of the gill arches. In this vicinity the mark *d* is found back of which I have not been able to fix the place with great accuracy since it was exactly in these eggs that the marks were lost when the medullary plate began to form. I could state however that these too do not appreciably move away from the animal pole, but that a small displacement seemed to take place in the direction of *b*, probably caused by the forming of the medullary plate and the accompanying thickening of the epithelium.

This shows that the third or equatorial cleavage in the egg of *Rana fusca* fairly well separates the head and the trunk, at any rate as far as the ectoderm is concerned. The rudiment of the head, taken as far as the gill slits, we find therefore in the four upper small blastomeres of the eight-celled stage, that of the trunk in the four large lower ones. Moreover it appears that the rudiment of the cerebral plate in stage 8 is found in the two smallest blastomeres of that stage, namely in the two animal and dorsal ones, each situated between the points *a*, *b*, and *d* and that these two blastomeres probably do not produce much more than just the cerebral plate. The two other animal blastomeres, the ventral ones, furnish the so-called sense-plate, i.e. the ectoderm of the head. Very attractive, also when viewing the pictures, is here the supposition that this sense-plate represents the remainder of the episphere of the trochophora. In this case the four animal cells of the eight-celled

stage of *Rana* would moreover in their prospective significance approximately agree with the corresponding four cells of the eight-celled stage of Annelida and Mollusca, i.e. with the so-called first quartet of micromeres, which in fact produces the top-plate. Still this supposition gives rise to considerable difficulties, which can only be overcome by additional suppositions. So e.g. the place of the mouth, which in Craniota lies behind the first body-segment, represented by the praemandibular mesodermic segment. Now if the supposition mentioned were right we should have to admit that the anterior mesodermic segments, as is the case in *Amphioxus* with the foremost point of the notochord, were pushed into the prostomium and that accordingly the mouth would also break through on the prostomium. For the olfactory grooves, which in Annelida lie on the border of prostomium and first segment, although occasionally a little way on the prostomium, a similar shifting would have to be admitted. This question seems for the present too difficult and too uncertain to be dealt with here.

So we see that while the rudiment of the cerebral plate originates in the animal half of the eight-celled egg, the rudiment of the remainder of the medullary plate is found in the four vegetative cells, chiefly of course in the two dorsal ones. This rudiment has, when the blastopore appears, the shape of a crescent, the largest breadth of which is measured by the distance between mark *b* and the blastopore lip. When the lip of the blastopore moves backward this maximum breadth increases proportionally to the distance between mark *b* and the rim of the blastopore. At the same time we may assume that just as the border of the blastopore goes on differentiating itself laterally from the cell-material there present, the crescentic rudiment of the medullary plate does the same, so that both horns of the crescent extend laterally backwards and finally almost join behind the blastopore. Meanwhile the possibility is granted that here a small gap remains, in regard to the eventual development of the anus from the posterior part of the blastopore. With the majority of more recent investigators I am of opinion that nothing pleads for concrescence taking place at the closure of the blastopore, unless at the very last when the blastopore occasionally assumes a pear-like shape, soon followed by the slit-shaped closure. I assume the caudally-excentric closure of the blastopore to be derived from a concentric, or perhaps even a rostrally-excentric one, such as is found in Annelida, by interference of this latter with a caudal shifting of the blastopore, which follows directly from my theory on the origin of the medullary canal from the stomodaeum of the Annelida and which is observed beautifully in Amni-

ota. In the same way as in Annelida the rudiment of the stomodaeum (WILSON, 1892, DELSMAN, 1916), so in Vertebrata the rudiment of the medullary canal (without the cerebral plate) lies in a crescent round the anterior border of the blastopore. The maximum breadth of this crescent continually increases during the closing of the blastopore and ultimately becomes the longitudinal axis of the medullary plate. I made different pricking experiments also during the closing of the blastopore, on which I shall not dwell here, since they did not lead to results deviating from those obtained by my predecessors ASSHETON, 1894, MORGAN and UMÉ TSUDA, 1894, EYCLESHYMER, 1898, WILSON, 1900, KING, 1902. They confirmed the above conception.

That the closure of the blastopore is identical with the gastrulation of the Chordata will not be doubted by any one who has occupied himself with the gastrulation process in different groups of Evertebrata. Still I wish to emphasize this, since on the question what gastrulation in the Chordata really is, opinions have recently been put forth and accepted, also in my country, which I think must be entirely rejected. So HUBRECHT (1905) and BRACHET (1905), following ASSHETON, support the conception that the gastrulation (in the form of a delamination) would be completed already when the first blastopore lip appears and that the closure of the blastopore — by concrescence, according to the former two — is entirely independent of the gastrulation, but according to HUBRECHT would correspond to the concrescence of the buccal slit of an actinia (theory of SEDGWICK-LAMEERE). For this process the name notogenesis is introduced and the blastopore is henceforth called notopore. Some compatriots of a younger generation (BOEKE, 1907, DE LANGE, 1907, IHLF, 1913) have accepted this nomenclature together with the conceptions of the lately deceased nestor of Dutch embryologists. As has already been stated, I cannot agree with these and other conceptions of HUBRECHT, however cleverly they combine ideas borrowed from LWOFF, HERTWIG, VAN BENEDEN and others, if it were only since in my opinion nothing pleads for and everything against concrescence, while moreover it has been sufficiently demonstrated that not at all the whole of the medullary plate, as BRACHET thinks, or the epichordal part of it, as HUBRECHT assumed, is formed over the blastopore. My own conception about the gastrulation process of the anamnia is evident from the preceding pages, which moreover show how excellently the results of the later investigations agree with the conclusions arrived at by my theory.

Is the cerebral vesicle of Amphioxus homologous with the brain of the Craniota? This question I put in a preceding paper (1913, b).

I then tried to show that the polar body in *Amphioxus* would be situated at a considerable distance before the neuropore. Now it has turned out, however, that also in *Craniota* the animal pole does not come on, but in front of the cerebral plate. Does not this invalidate my former reasoning? In no way. If the reader will take the trouble to compare the two pictures of *Amphioxus* embryos reproduced in that paper, he will perceive at once that there can be no question that in *Amphioxus* the polar body will obtain a place corresponding to a mark on the animal pole of the frog egg, i.e. exactly in front of the neuropore. The distance from the neuropore is so large that it entirely agrees with the ideas then put forth by me and which are moreover supported by strong anatomical arguments, according to which the fore-brain proper of the *Craniota* is lacking in *Amphioxus*. As well in *Annelida* as in *Acrania* and *Craniota* we find that the animal pole finally lies approximately on the foremost point of the prostomium and therefore also of the body.

Finally a single experiment may still be mentioned, which I hope to extend later, but which already can confirm a conclusion lately reached by BRACHET in a different way. On the fertilised but still unsegmented frog egg a bilateral symmetry is soon observed, caused by the white — in the form of the so-called grey field (Roux) — extending on one side, the dorsal one, higher up towards the egg equator than on the other sides. In the majority of cases the first cleavage plane coincides with the plane of symmetry of the unsegmented egg and the symmetry-plane of the embryo is then in its turn the same as these two. Such eggs with "typical" development (Roux) I always selected, as was stated above, for the marks *a*, *b*, *c*, or *d*. Variations are not very rare, however, the first cleavage plane sometimes making a more or less considerable angle with the symmetry-plane of the egg, which angle may amount to 90° (anachronism of the two first cleavages). Now BRACHET by killing one of the first two blastomeres by means of a hot needle and by studying the so formed hemi-embryos, arrived at the conclusion that in such cases, in which the symmetry-plane of the egg and the first cleavage plane do not coincide, the symmetry-plane of the embryo corresponds to that of the egg and is independent of the direction of the first cleavage plane. This conclusion is confirmed by what follows.

I came across an egg in the eight-celled stage in which the highest point of the white field did not lie on one of the two vertical cleavage furrows, as is the case with typical cleavage, but halfway between the two, hence not under point *b*, but halfway between *b* and one of the *d*'s. Evidently the first and also the second division

had made here an angle of 45° with the symmetry-plane of the egg. Perhaps a couple of strong mutually perpendicular cross-lines ("Brechungsfurchen") at the animal and vegetative poles were also a result of this. Now I made a small mark on the equatorial cleavage furrow over the highest point of the "grey field", i.e. halfway between two points of intersection which may best be denoted by b and d , although in such a case this nomenclature does not hold, of course. The result was what might be expected according to BRACHET: the mark behaved entirely as a mark made at b in a "typical" egg. The blastopore lip was formed

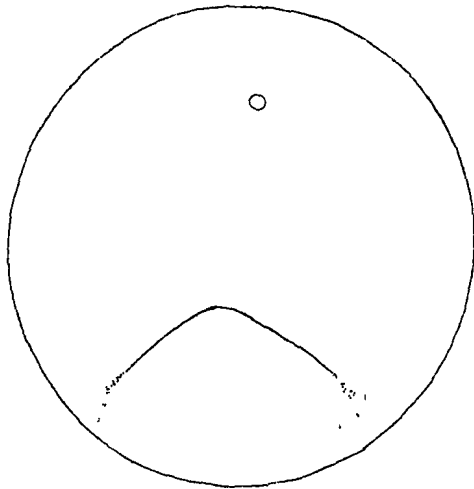


Fig. 3.

For explanation see the text.

Little mark right above the crescent-shaped blastopore border.

and contracted right under it (fig. 3) and finally lay on the middle of the medullary plate, just behind the cerebral plate. Hence the symmetry-plane of the embryo coincides with that of the unsegmented egg, independent of the direction of the first two cleavages. I hope very much that future years may offer an opportunity for continuing and extending these experiments, which are a first attempt to attain at something like cell-lineage investigations in vertebrates. Also on eggs of *Rana esculenta* I made some

preliminary experiments, the results of which are very interesting and will be published shortly.

For the present it may be stated that between the directions of the first two cleavage planes and those of the main axes of the embryo no direct and constant relation exists. Such a relation does exist, however, between their line of intersection, the main axis of the egg, with which the longitudinal axis of the embryo (as long as the tail has not begun to develop) coincides. This also holds for the third cleavage plane which approximately separates head and trunk and to which accordingly a greater prospective significance must be attributed than to the former two.

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Physics. — "*Electrolytic phenomena of the molybdenite-detector.*"

By M. J. HUIZINGA. (Communicated by Prof. HAGA)

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In an inquiry into the cause of the unipolar conduction of crystal-contacts, which are used as detectors in the techmics of wireless telegraphy, it was tried to demonstrate the existence of a secondary E. M. F. when the primary current had ceased.

To this purpose a current of some milliamperes was for some time sent through a crystal-contact, the electrodes of which were connected to a galvanometer after stopping the current. This experiment was repeated with a reversed primary current. Whereas the deflection of the galvanometer in all other combinations inquired into was not worth mentioning, it was very large in a molybdenite-brass detector; even when the primary current had passed during part of a second only. This deflection changed, both in direction and magnitude, when the primary current was reversed. An electrometer taking the place of the galvanometer indicated 0,7 volt; as the five-cellular quadrant-electrometer, which was used, has a large capacity, the potential difference between the electrodes is undoubtedly larger; such an E. M. F. can hardly be explained by thermo-electric forces.

When, after many experiments with the same contact, a small dark-coloured spot had begun to show round about the brass point, the place of contact was observed during the passage of the primary current in a microscope magnifying thirty times.

It proved to be very fit to let a piece of the mineral float on mercury and to put upon it a platinum point with slight pression. If, now, a current of some milliamperes is sent through the contact from MoS_2 to Pt , then, after some moments, in some cases after