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The Processes of Involution in the Gills of the Axolotl (Amblystoma mexicanum Cope)

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The Processes of Involution in the Gills of the Axolotl (Amblystoma mexicanum Cope)[1].

By
A. Grotans.

(2 plates.)

Contents:

It has been known already for some time that specimens of Axolotl are met with whose gills differ considerably from the normal size. For instance *Wurmbach* states (1926):

«Die Verletzlichkeit der Kiemen ist eine sehr grosse. Dadurch, dass sie weit vom Körper abstehen und durch das Fehlen jeglicher Skelettsubstanz in ihnen wird ihr Verlust leicht ermöglicht. So verlor auch einer von meinen Axolotl schon sehr jung durch den Biss eines seiner Genossen eine Kieme. Noch auffälliger geht die leichte Verletzlichkeit der Kiemen der Axolotl daraus hervor, dass von 12 von Scholze und Pötzschke bezogenen Axolotln nur noch 4 ihre erste Kiemen besassen. Bei allen anderen waren sämtliche Kiemen verkürzt und trugen Regenerate, die leicht kenntlich sind dadurch, dass an breiteren Basis plötzlich ein schmäleres Stück ansetzt».

However, besides these cases of mechanical injury gills of special shape are produced also in consequence of processes of involution.

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[1]) Abstract of a lecture at the Latvian Biological Society on May 5-th 1934.

The classical case, when in 1865 at the Paris Jardin des Plantes an Axolotl changed into an Amblystoma (cf. *Brehm)* is not only of interest, because it helped to fix the position of the Axolotl in the zoological system, but it is also the first recorded observation of a case of involution in an Axolotl.

In recent literature we also find descriptions of some cases of involution but we have no observations of the involution process itself.

The main object of this report is the histological comparison of the involution processes observed in the gill lamellae of Axolotl with similar phenomena in the tail folds of Amphibia *(Barfurth, Noetzel, Looss* and *Dennert)* as well as the record of some macroscopical observations during the involution of gills.

My sincere thanks are due to my chief — Professor Dr. *N. G. Lebedinsky* for his kind assistance during my work and many helpful suggestions and advice.

I. Material and Methods.

Macroscopical observations were made on the gills of 12 white and 5 dark coloured Axolotls.

The duration of experiments was approximately 2½ years. According to the speed of the involution process the actual observations were made once in 1 to 30 days. For the purpose of measurements the animals were rendered unconscious in water containing 2 to 4 p. c. of ethyl ether. For the inspection of the gills a binocular magnifying-glass enlarging 3 times was used. The measurements were made with a small piece of a measuring ruler whose construction corresponded that of transvers scale with an accuracy of the readings up to 0,1 mm.

Subsequent comparison of the results of several measurements of the same gill enabled me to judge of the changes which had occurred.

The Axolotls were kept in a zinc tank provided with running water. Its size was 150 cm. by 75 cm. and the water was kept 14 cm. deep.

As materials for histological investigations were used 6 white and 2 dark specimens. The gill lamellae were fixed in *Bouin's* fluid. The staining of the series of paraffin slides was done with haematoxylin and eosin. *Mallory's* method was also employed.

II. Macroscopical Observations.

We may study the progress of the involution of gills by comparing those which are subject to regressive development with normal ones.

As is well known the normal proportions of Axolotl gills (Fig. 1) are as follows:

The gills on both sides of the body develop simultaneously and grow at the same rate. The length of branchial bars and the number of lamellae increase in the anterio-posterior direction i. e. from the first to the third pair of gills. Often between the second and third pair of gills hardly any difference could be observed. The length and width of the lamellae of the first pair of gills is the smallest, on the other two they are nearly equal. On each separate gill the length of the lamellae decreases from the basal end of the bar towards the distal end.

The involution process of a gill starts in such a way that the pink ends of the lamellae turn light yellow or white. Next the dimensions of the lamellae decrease, especially their length. The involution does not occur equally on the whole branchial bar: the lamellae on the distal end of the bar are more often affected whilst at the basal end there may be no change at all. Also the different pairs of gills of the same specimen are usually not equally inclined towards involution. The lamellae of the third and second pair are more often affected than those of the first pair.

The involution of the branchial bars starts when the lamellae on their distal end are already very much reduced. At this time of the 1 to 2 mm. long lamellae only hardly noticeable stumps are left. At the beginning of the process we observe a spiral rolling up of the pointed end of the bar or a simple bending of the bar in a varying degree. The reduction of the bar occurs mainly on its distal end, and a simultaneous reduction of the basal part was not observed. The reduction of the bars of the third and second pair is common but the first pair of gills often retain their normal dimensions during the whole process and often also after it. A complete reduction of gills I did not succeed in observing. Therefore the problem remains unsolved whether the varying speed of the involution observed on the different pairs of gills is maintained also further on or whether all pairs of gills complete this reduction simultaneously.

As a result of involution we see gills which differ from normal ones by their bars being short and thick. The bars of the first pair often exceed the others in length — and instead of a gradual decrease of dimensions of lamellae we meet some kind of irregular changes of size.

During 2½ years were observed the following changes on the gills of 17 specimens (12 white and 5 dark ones): During this time the well-developed lamellae of two fullgrown dark specimens decreased in width a little and in length by one fifth but the branchial bars retained their former size. The gills of the other three dark specimens, which were older, did not show any changes. The involution of the quite normally and well developed gills of three white specimens started at the begining of August in the first year of the experiment. Within a month the bars of their second and third pair of gills decreased by one third in length and the lamellae on the basal part of these bars by one fourth, but on the distal part by one half and at the extreme distal end they practically disappeared, leaving hardly noticeable elevations. The bars of the first pair of gills retained their full size but the lamellae lost in length about one sixth part. The gills have remained ever since in this condition without any further change.

The dimensions of the normally developed gill bars of average size of three other specimens never changed, but the lamellae of the third and second pairs of gills used to decrease a little in length during the months of October and November but in spring, usually in May, recovered their former size.

The involution of the lamellae of a white Axolotl started in January at a very fast rate. In about 1½ months the 5 mm. long lamellae were reduced to 1 mm. but the short bars did not show any change. In the same year in May was observed an increase of the lamellae and at the end of June they had recovered the length of 9 mm. and are still in that condition.

Two other animals with 1—2 mm. long lamellae and three further individuals with lamellae of average size have shown no changes during the time of observation. In general I could observe that the white Axolotls were more liable to involution of gills than the dark ones which no doubt are the normal natural parent form of the white ones.

The causes inducing involution may be various.

Winterstein's (1921) observations show that small Amblystoma larvae develop only very small gills when living a long time in water enriched with oxygen by ventilation.

Further we may note the observations of compensatory hypertrophy of the gills of the frog, salamander and Amblystoma larvae after amputation of parts of gills recorded by *Merkel* (1925) *Feldotto* (1926), *Vilas* (1928) and *Grotans* (1933, 1934). This phenomenon was observed on the non-amputated gills. Compare also *Pržibram* («Regeneration») and *Lebedinsky* («Isopotenz»).

Barfurth states that the capacity for regeneration of Amphibia almost entirely disappears below 10° C. but gradually increases at 10° to 28° C. Also the observations of *Grotans* (1933, 1934) confirm the large dependence of the speed of regeneration on temperature.

All quoted observations support the view that the dimensions of gills are affected by the conditions the animal is living in. When the reduction of gills occurs simultaneously with changes of conditions (seasons) the fluctuation of the temperature between winter and summer must be accepted as cause of involution.

Another cause of the reduction of gills of Axolotl may be their tendency to change into adult Amblystoma which process is concurrent with the disappearance of gills. It is possible that the three specimens which started to reduce their gills in August, when the temperature was the same as in July, were under the influence of metamorphosis.

I have also to note that in the course of all my work I never observed an animal being seized by another at the gills.

Further I have never noticed a branchial bar having been wounded, for which reason I consider that during my experiments — also in my absence — gills have never been seized. Of course I do not deny the possibility of it.

On this point the observations of *Feldotto* (1926) are of value. He examined 500 young tadpoles collected in their natural environment and found among them 26 p. c. with damaged or lost gills. But among 150 tadpoles raised in glass vessels were found 3 animals with damaged gills.

III. Histology of Gill Lamellae.

1. Normal Lamellae.

Data on the histology of normal gill lamellae have been supplied by *Carriere* (1885), *Clemens* (1894), *Gegenbauer* (1901), *Faussek* (1902), *Oppel* (1905) and *Wurmbach* (1926). The shape of a cross section of the lamellae is subject to wide variations (fig. 1, 2, 3, 18, 20—22). Most common are cases, when their width exceeds by 3 to 9 times their thickness. Of extreme cases I met instances when the cross section hardly differed from a circle. On the other hand I observed also such, whose width exceeded by 10 times the thickness.

Especially at the distal ends width and thickness are nearly equal (fig. 5, 19). In most cases both the surfaces forming the width of the lamellae appear in the cross section parallel or slightly concave (fig. 1), more rarely both surfaces are convex, or the one convex and the other concave (fig. 1 and 4). On the other hand both sides of the lamellae (in cross section) are always more or less of semicircular shape.

Carriere, *Clemens* and *Faussek* record a 1—2 layers thick epidermis of the lamellae. *Wurmbach*, on the contrary, writes: «Das Epithel der Kiemenblättchen ist an ihrer Basis mehrschichtig, verdünnt sich aber stark nach deren Spitze hin und wird zweischichtig, an einigen Stellen sogar anscheinend einschichtig».

My series of slides of the longitudinal and cross sections of the lamellae did not confirm the observations of *Wurmbach*. In the most part of the slides I could find on the whole length of the lamellae a 1—2 layers thick epidermis (fig. 7 and 8). The epidermis of the involuting lamellae, on the contrary, differed widely from the normal one, as will be seen later. In the involuting lamellae I could not find also the gradual decreasing of the number of cell-layers from the base to the end of the lamellae. In the cross sections of the normal lamellae the cells are close one to another. The inner and outer surfaces of the epidermis are even and the jelly tissue and blood-vessels, which are found deeper in the lamella, differ sharply from the epidermis (fig. 1, 2, 4). In the cross section of the lamella the nuclei of the epidermis cells are located with their length parallel to the longer axis of the cross section.

The location and size of the main blood-vessels of the lamellae are not the same on all microscopical slides. The size of the main blood-vessels may in lamellae of the same size exceed one another up to 9 times. On most of my slides both main blood-vessels are situated very near to the epidermis and only rarely nearer towards the centre of the lamella. About 6 to 15μ from the distal end of the lamella these two vessels join one another without the aid of capillaries (fig. 5, 6). Further I observed some correlations between the two blood-vessels and the capillary system. In cases when the capillary system was well developed both main blood-vessels were often so slightly developed that they were hardly differing from the former. On the other hand on slides showing weakly developed capillary system the dimensions of the main blood-vessels were usually considerable (fig. 1, 2).

However, all kinds of irregularities were also met with: Lamellae with well developed main vessels and capillaries and some in which the whole cirulatory system was deficient. Twice a peculiarity was met with: one of the main vessels branched and after a short distance the two branches joined again (fig. 3).

The remaining part of the lamellae consists of a jelly-like connective tissue and a connective tissue with collogenous and elastic fibres. The fluctuations in thickness of the lamellae seem to be dependent primarily on the quantity of jelly tissue present, because even in the case of thick lamellae I could not observe any change in thickness of the epithelium.

The lamellae of the dark Axolotl contain a pigment whilst those of the white ones are without it. The grains of pigment are often situated along the inner walls of the main blood vessels and also between capillaries and in the jelly tissue. In several lamellae between the cells of the epidermis I also observed one-celled mucous glands.

2. *Involuting Lamellae.*

There are hardlly any data concerning the histology of involuting gills. Only *Kornfeld* (1914) has published a few observations on the changes of the system of blood circulation of the gills of Salamandra maculosa during metamorphosis. Much more information is available concerning the reductive processes in the tails of Amphibia in the works of *Barfurth* (1887), *Loos* (1889), *Noetzel* (1895), *Saguschi* (1915) and *Dennert* (1920).

First of all we will review the process of disintegration of the epidermis of the gill lamellae of an Axolotl. In the first phase of the process the cells of the epidermis cease to touch one another as closely as they did before and produce an irregular and loose inner and outer surface of the epidermis (fig. 12, 13 and 14). On slides of cross sections of the lamellae the nuclei of cells are no longer situated with the longer axis of their section parallel with the longer axis of the cross section of the lamella but perpendicular to it (fig. 13 and 14).

The cells of the epidermis show a tendency to migrate towards the centrally situated jelly tissue. The transmutation of these cells into the jelly tissue starts with a preliminary reduction of their size (fig. 19, 20, 21). All round a cell appear empty intercellular cavities. For a time the cell is kept in its former position by bridges of protoplasm. Upon these connections breaking the nuclei of the cells travel deeper into the body of the lamella — finally to join the jelly tissue. The degeneration of the cells of the epidermis continuing, some of the constituents of the epidermis more or less fill the jelly tissue (fig. 12, 13, 14, 15, 19, 20). The degeneration of the epidermis nearing its end, the boundary between epithelium and jelly tissue disappears entirely (fig. 20, 21) and the epithelium consists of several layers. Besides, an outward bound migration of some constituents of cells of the epithelium has been observed (fig. 12 and 16). Similar migration of cells has been observed on microscopical slides of normal lamellae too.

The disintegration of the epithelium of Axolotl lamellae usually goes on everywhere uniformly. However, on some slides I could observe diminished involution in the basal part of a lamella and within a cross section the rate of the involution process was variable (fig. 22) viz. the intensity was greater either on the side of the longer (fig. 17) or the shorter (fig. 14, 18) axis of the section. Besides, there were cross section slides showing a faster speed of involution within a small sector of a lamella (fig. 16). And on one occasion I observed the involution process only in the central part of a lamella (fig. 10, 11).

According to the data of several authors, in the fold of the tail of amphibia towards the end of the reduction process the limits between the epithelium, corium and layers of connective tissue lose their former distinctness. There has also been recorded the increase of the number of the layers of the epidermis (even up to 18).

Considerable changes occur in the blood-vessels of the lamellae. As has been already mentioned, the two main blood ducts join one another without the aid of capillaries about 10μ before the top of the lamella (fig. 6) and terminate.

In involuting lamellae the two main vessels do no longer join one another and terminate separately, each on its own side of the lamella, about 45 to 70μ before the distal end of the lamella (fig. 19 and 20). The width of the vessels is much reduced (cf. fig. 1 and 2 with fig. 12, 15 and 20) and there are in them no blood corpuscles at all or only very few of them. On the other hand blood corpuscles can be also observed outside the blood-vessels in the jelly tissue (fig. 10 an 11). The capillary system disappears entirely from the distal end of the lamella (fig. 19), but in the middle part the capillaries often fuse together and directly connect the main blood-vessels (fig. 21). The latter were often situated more centrally within the lamella than normally.

In several microscopical slides could be observed either exactly in the centre of the cross section one vessel (fig. 14) or two, close one on either side, filled with blood corpuscles (fig. 14 and 18). The origin of these new blood-vessels is not clear to me. In these slides the large blood-vessels situated quite normally each on its side of the lamella were usually quite free of blood corpuscles.

In general, the jelly tissue of degenerating lamellae contained a large number of cavities — which on microscopical slides had the appearance of colourless spots (fig. 13 and 17). It is possible that the new ducts near the axis of the lamella were formed by the fusion of these cavities. Within the limits of my investigations the involution process of the lamellae of Axolotl went on as follows. First of all could be observed the disappearance of blood corpuscles from the vessels of the distal end of a lamella (fig. 12, 14, 15). Some time later the epidermis of the lamella became loose in consistency and its surfaces, both inner and outer, became irregular (fig. 12, 13, 14). Next the degenerating epithelium cells of the distal part of the lamella moved centripetally, filling the jelly tissue and later also the cavities of the reduced two main blood-vessels and the capillaries. In the basal parts of the lamella are also formed multiple layers of epithelium in part by way of migration of epidermis cells from the distal end. Simultaneously with the accelerated speed of the involution process at the distal end of a lamella the process is in progress also in other parts, but the intensity of it decreases towards the basal part (fig. 22). Thus the above stated course of the involution process corresponds with analogous observations by *Barfurth, Loos, Noetzel* and *Dennert* on the tailfolds of tadpoles of amphibia.

Loos expresses the opinion that the involution process in the tailfold of amphibia does not go on continuously but by way of a series of separate impulses, whilst *Dennert* describes the process as uninterrupted. It is difficult to say whether in the case of an Axolotl gill lamellae we meet with phenomena corresponding to views of both *Dennert* and *Loos*. We had cases when continuity of the process till a complete degeneration of a lamella seemed to be a possibility, and cases when the process stopped, followed later by a resumption of it. But we also observed cases when instead of a further step towards degeneration the lamellae recovered their former size.

Nearing the completion of the involution process the differentiation of tissue — on microscopical slides of lamellae — diminished and they coalesced into a homogeneous mass (fig. 23).

Metchnikov, *Barfurth* and *Loos* ascribe to the leucocytes some part in the process of absorption of the products of destruction during involution. On the other hand *Dennert* does not recognize any important röle of the leucocytes. On my slides I also rarely saw leucocytes.

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Thus we see, that in the changes of shape and structure of the gills of Axolotl the involution process plays an important röle. The main causes of the reduction of the gills are the inclination of the animal towards metamorphosis and changes of conditions of environment (seasonal changes, change of location etc.).

The second and third pair of gills are more liable to involution and this process occurs more often with white Axolotls than with the dark pigmented ones.

The epidermis of normal gills of Axolotl consists all over the lamellae only of 1—2 layers. Both main blood-vessels join one another at the distal ends of the lamella.

The involution progresses mainly from the distal end of lamellae towards the basal one although the process occurs in diminished degree in all parts of it. Sometimes this process is more pronounced on one side of a lamella and less on another. As a result of reduction we observe fundamental changes in the histological structure of lamellae.

IV. Summary.

A. Macroscopical Observations.

The gills of Axolotl, and especially the lamellae, are liable to reduction or increase in size in consequence of external influences, as changes of seasons and environment. The cause for the reduction of gills — even if it is incomplete, may be the tendency towards metamorphosis.

The involution process starts with the reduction in size of the lamellae at the distal end of a bar, followed by the reduction in size of the bar itself. Involution occurs most often with the second and third pairs af gills and the white breed of Axolotl is more liable to it.

B. *Histological Observations on Normal Gill Lamellae.*

The epidermis of the whole lamella consists of 1—2 layers only. On several slides it was observed that the number of epidermis layers shanged in the longitudinal as well as the transverse direction of a lamella.

The main blood-vessels join one another about 10μ before the end of the lamella. There was observed a reverse relation between the dimensions of the main blood-vessels on the one hand and the dimensions and number of capillaries on the other hand.

C. *Histological Observations on Reduced Lamellae.*

The involution process progresses mainly from the distal end of a lamella towards the basal end and, although to a lesser degree, also in the whole of it. The epidermis of the lamella becomes loose in consistency and its outer and inner surfaces both get uneven. On cross section slides of lamellae the cell nuclei of epithelium cease to be located with their longitudinal axis parallel to the longitudinal axis of the cross section, but at right angles to it. Then starts the reduction in size of single epithelium cells, but towards the end of the process the protoplasm bridges connecting the degenerating cells with the adjoining ones break away and the cell freely moves away in the basal direction to join the jelly tissue. Thus the distal part of a lamella becomes gradually filled with remnants of degenerated epithelium cells. When the reduction has progressed the epithelium of a lamella consists of many layers. Besides, the speed of degeneration might be considerable at one end or side of a lamella whilst at another very slight.

Finally the blood-vessels and capillaries at the distal end of a lamella disappear entirely. The conjunction between the two main blood-vessels disappears at the distal end and they terminate each on its own side of the lamella already 45 to 70 μ before the end of it. Often the capillaries connect up the two main vessels within the middle part of the lamella. Besides, in the central part of the lamella are often formed one or two new blood-vessels which — on our slides — were full of blood corpuscles. Also an outward bound migration of epithelium cells of the lamellae has been observed. In general the involution processes within the gills of Axolotl correspond to similar phenomena in the tails of tadpoles of amphibia, as described by *Loos, Noetzel and Dennert.*

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Explanations to Plates 1 and 2.

Fig. 1. Typical normal gills of an Axolotl.

Fig. 2. Some gills of a white Axolotl during involution.

Fig. 3. Lamellae of normal gills. When not stated otherwise: cross section of a lamella of the white breed.

a — Epidermis. b — Blood-vessels. c — Capillaries.

Fig. 4. Lamellae of normal gills. The correlations of width and thickness are other than in fig. 1. Both main blood-vessels are well developed.

Fig. 5. On the left side of the cross section is seen a double blood-vessel.

Fig. 6. A dark coloured Axolotl, a — pigment.

Fig. 7. A dark Axolotl. Cross section of a lamella some 30—35 μ from distal end.

Fig. 8. A dark Axolotl. Cross section of a lamella at about 10 μ distance from distal end. Distictly visible the junction of the two main blood-vessels.

Fig. 9. A cross section of the gill bar somewhere in the middle of the distal part of it. Longitudinal section of lamella. Epidermis in 1—2 layers.

Fig. 10. Longitudinal section of a lamella. Epidermis has 1 to 2 layers.

Fig. 11. Part of a longitudinal section of a lamella. One-celled mucous glands.

Fig. 12. The first stage of the involution process.

a — Epidermis (loose consistency), b — blood-vessels (considerably reduced, free of blood corpuscles), c — capillaries still containing blood corpuscles, d — jelly tissue containing remnants of epidermis cells (nuclei), e — epidermis cells migrating outward.

Fig. 13. The first stage of involution; loose and uneven epidermis. The axis of longitudinal sections of nuclei are at right angles to the longer axis of the section of the lamella. In the jelly tissue new cavities have been formed.

Fig. 14. The first stage of involution. The inner surface of the epidermis uneven — in ripples. The axal blood-vessel containing blood corpuscles.

Fig. 15. The first stage of involution. The jelly tissue already partly filled with constituents of the decomposing epidermis.

Fig. 16. First stage of involution. Pronounced involution of the epidermis only in one sector of the cross section of a lamella. Main blood-vessels considerably reduced, outward bound migration of epidermis cells.

Fig. 17. First stage of involution. Increased rate of the involution of epidermis only on one side of the longitudinal axis of the cross section of a lamella.

Fig. 18. First stage of involution. Increased rate of the involution of epidermis only on one side of the shorter axis of the cross section of the lamella.

Fig. 19. Longitudinal section of a lamella during the first stage of involution. Increased involution of the epidermis in the middle of the lamella. Blood corpuscles visible in the jelly tissue. («Passive Diapedesis» according to *Metchnikov*).

Fig. 20. First stage of involution (corresponding to an area of increased involution of fig. 18) Jelly tissue full of remnants of destroyed cells of epidermis and blood corpuscles.

Fig. 21. At a later stage of the involution process about 25 to 30μ before the top of a lamella. The blood-vessel on one side of the lamella has disappeared entirely, but from the other main duct is still left some small remnant. Jelly tissue full of remnants of epidermis cells.

Fig. 22. Somewhere in the middle part of a lamella at a later stage of involution. The decomposing epidermal cells are surrounded by intercellular cavities. Both blood-vessels much degenerated. The capillary system has disappeared already. Between epidermal cells filling jelly tissue some blood corpuscles visible.

Fig. 23. Somewhere in the middle part of a lamella at a late stage of involution. A capillary connects directly both the main blood-vessels.

Fig. 24. The basal part of a lamella in the last stage of involution process. The differentiation of tissue decreases and they coalesce into one homogeneous mass.

Fig. 25. During the middle stage of the involution process. Can be seen distinctly the decrease of the extent of involution towards the basal part of a lamella and fluctuations across the middle part of it.

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Involūcijas procesi aksolotlu (Amblystoma mexicanum Cope) žaunās.

Kopsavilkums.

A. Grotans.

A. Makroskopiski novērojumi. Aksolotlu žaunas un it sevišķi žaunu bārkstiņas reducē vai palielina savus apmērus atkarībā no ārējiem dzīves apstākļiem (gada laiku vai dzīves vietas maiņa u. t. t.). Žaunu atpakaļattīstībai, kaut arī nepilnīgi, var būt arī kāpura tendence uz metamorfozu.

Involūcijas process iesākās ar kātiņa distālā daļā novietoto bārkstiņu samazināšanos, kam seko arī kātiņa apmēru redukcija. Involūcija biežāka otram un trešam žaunu pārim un arī baltai rāsai.

B. Normālu žaunu bārkstiņu histoloģija. Visā bārkstiņas garumā epidermis ir 1—2 kārtains. Vairākos preparātos varēja saskatīt epitēla kārtu svārstīgumu, kā bārkstiņas šķērsvirzienā, tā arī garvirzienā.

Galvenie bārkstiņas asinsvadi apmēram 10 μ atstatumā no bārkstiņas distālā gala pāriet tieši viens otrā. Novērojama apgriezeniska attiecība starp bārkstiņas galveno sānu vadu apmēriem no vienas un kapillāru lielumu un daudzumu no otras puses.

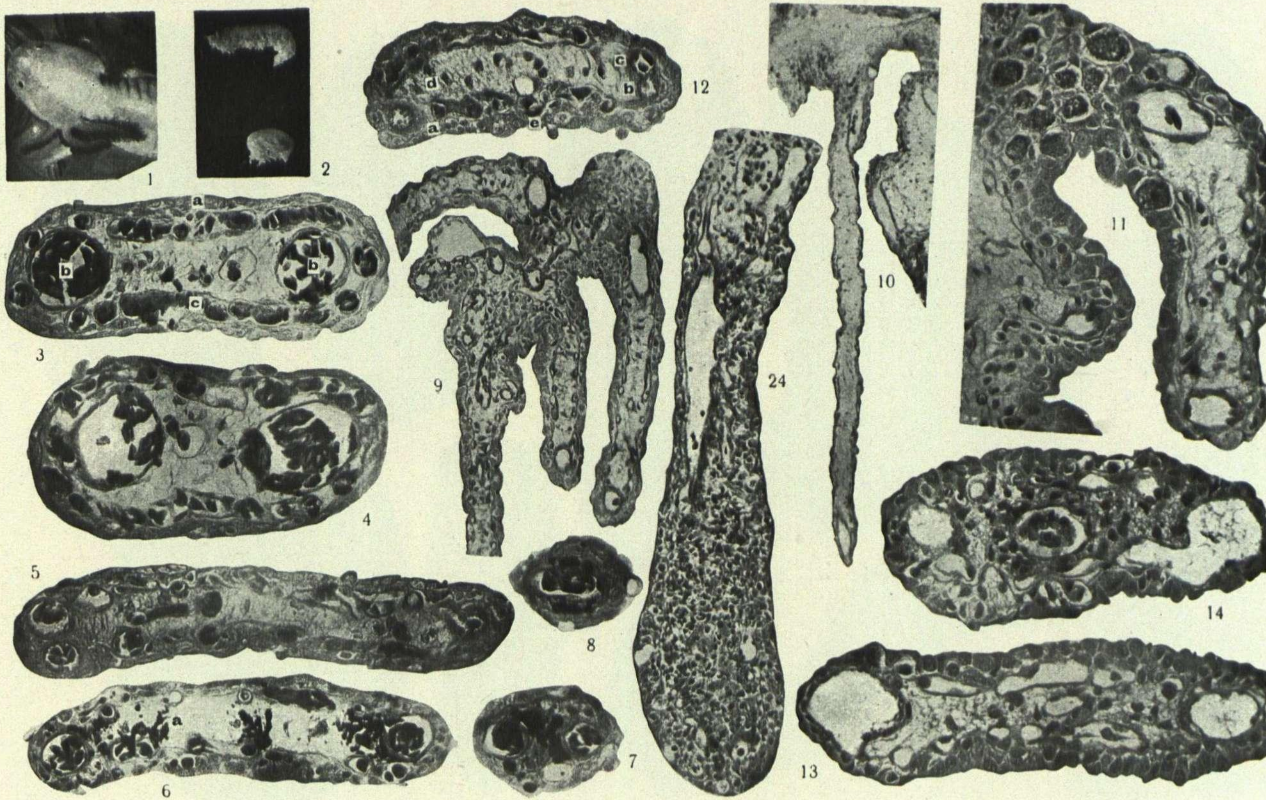
C. Reducētu bārkstiņu histoloģija. Involūcija norit galvenā kārtā no bārkstiņas distālā uz bazālo galu un arī, lai gan mazākā mērā, visā bārkstiņā. Bārkstiņas epiderms kļūst irdens ar nelīdzenu, grumbuļainu ārējo un iekšējo virsmu. Bārkstiņas šķērsgriezumā epitēlšūnu kodoli nav vairs novietoti ar savu gareno asi paralēli šķērsgriezuma garākajai asij, bet gan perpendikulāri. Tālāk iesākās atsevišķu epitēlšūnu apmēru samazināšanās; kamēr beigās pārtrūkst deģenerējošo šūnu protoplazmas atzarojumu saistība ar kaimiņu šūnām un šūna brīvi pārvietojas bazāli, t. i. galertaudos.

Tādā kārtā bārkstiņas distālā daļa pakāpeniski piepildās ar deģenerējošo epitēlšūnu elementiem. Turpinoties redukcijai, visa bārkstiņa pārklāta ar daudzkārtainu epitēlu. Bez tam deģenerācijas ātrums var būt bārkstiņas vienā malā vai sānā paātrināts, kamēr otrā vājāki izteikts.

Distālā bārkstiņas daļā asinsvadi un kapillāri beidzot pilnīgi izzūd. Bārkstiņas abu galveno asinsvadu savienošanās vairs nenotiek un tās izbeidzās katra savā malā jau 45—70 μ atstatumā no bārkstiņas distālā gala. Bārkstiņas vidus daļā asins kapillāri bieži tieši savieno abus minētos sānu vadus. Bez tām bārkstiņu asī izveidojās viens vai divi jauni asinsvadi, kas preparātos bij pildīti ar asins ķermenīšiem. Tāpat novērota bārkstiņas epitēlšūnu emigrācija uz āríeni.

Tuvojoties involūcijas procesa noslēgumam, bārkstiņu preparātos vērojama audu kontrastainības mazināšanās un saplūšana homogenā masā.

Visā visumā involūcijas procesi aksolotlu žaunās norit vienādi ar *L o o s'a, N o e t z e l'a* un *D e n n e r t'a* darbos aprakstītiem abinieku kurkulēnu astes involūcijas procesiem.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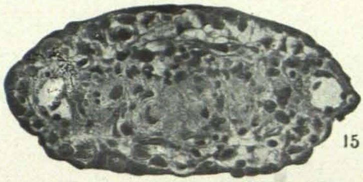

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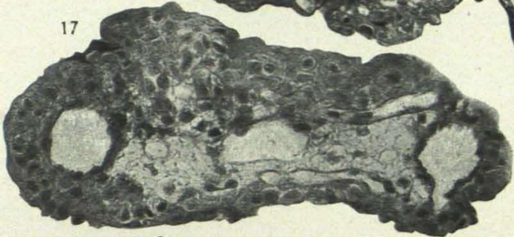

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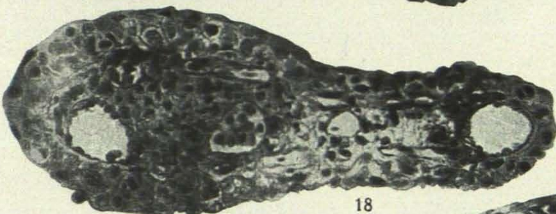

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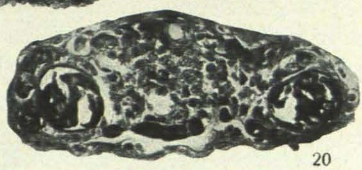

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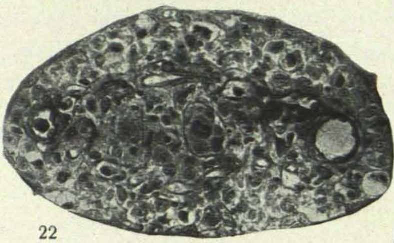

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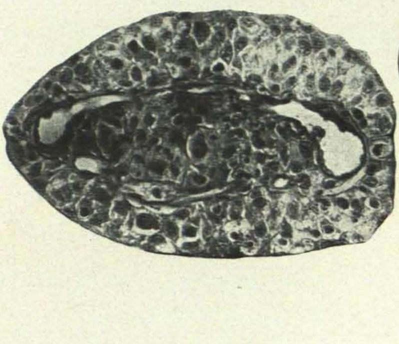

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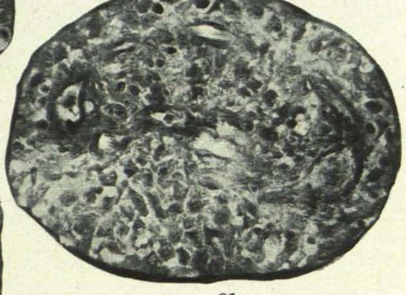

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