Where the ink has been is now less active than the rest of the plate. Here are slides which show these positive and negative pictures. Another way of modifying the zinc surface is interesting. You have seen that the ordinary zinc surface which has been exposed to air and moisture is quite inactive, but if a bright piece of zinc be immersed in water for about twelve hours, the surface is acted on; oxide of zinc is formed, showing generally a curious pattern. Now if the plate be dried, it will be found that this oxide is strongly active, and gives a good picture of the markings on the zinc. The oxide evidently holds, feebly combined or entangled in it, a considerable quantity of the hydrogen peroxide, and it requires long drying or heating to a higher temperature to get rid of it. Also, if a zinc plate be attacked by the hydrogen peroxide, the attacked parts become more active than the bright metal. Thus place a stencil on a piece of bright zinc, and expose the plate to the action of an active plaster of Paris slab, or to active blotting-paper for a short time, then, on removing the stencil, the zinc plate will give a very good picture of the stencil. Any inactive body—for instance, a piece of Bristol board or any ordinary soft paper—can be made active by exposing it above a solution of peroxide, or, more slowly, by exposing it to a bright zinc surface. If, for instance, a copper stencil be laid on a piece of Bristol board, and a slab of active plaster of Paris be placed on the stencil for a short time, the Bristol board will even, after it has been removed from the stencil for some time, give a good picture of the stencil. Drying oil and other organic bodies may be used in the same way to change the paper. A curious case of this occurred in printing a colored advertisement cut out of a magazine, for there appeared printing in the picture which was not in the original. This printing was ultimately traced to an advertisement on the opposite page, which had been in contact with the one which was used; thus this ghostly effect was produced.

I believe, then, that it is this active body, hydrogen peroxide, which enables us to produce pictures on a photographic plate in the dark. There are many other curious and interesting effects which it can produce, and which I should like to have shown you, had time permitted.

I would only add that this investigation has been carried on in the Davy Faraday Laboratory of this Institution.

William James Russell.

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## *DEGENERATION IN THE EYES OF THE COLD-BLOODED VERTEBRATES OF THE NORTH AMERICAN CAVES.**

"Degeneration," says Lankester, "may be defined as the gradual change of the structure in which the organism becomes adapted to less varied and less complex conditions of life; whilst elaboration is a gradual change of structure in which the organism becomes adapted to more and more varied and complex conditions of existence."

Degeneration may affect the organism as a whole or some one part. I propose to speak not on degeneration in general but to give a concrete example of the degeneration of the parts of one organ.

The eyes of the blind vertebrates of North America lend themselves to this study admirably because different ones have reached different stages in the process, so by studying them all we get a series of steps through which the most degenerate has passed. This enables us to reach conclusions

* Presidential address at the meeting of the Indiana Academy of Sciences, Dec. 27, 1899. The detailed account of the eyes, whose general features are given here, has in part been published in Roux's Archiv f. Entwickelungsmechanik, VIII., and will in part be published in the Proceedings Am. Microscopical Society for 1899.

that the study of an extreme case of degeneration would not give.

I shall confine myself to the cave salamanders and the blind fishes (Amblyopsidæ) nearly all of which I have visited in their native haunts. The salamanders are introduced to illuminate some dark points in the degeneration of the eyes of the fishes and to emphasize a fact that is forcing itself forward with increasing vehemence, *i. e.*, that cross-country conclusions are not warrantable, that the blind fishes form one group and the salamanders other groups, and that, however much one may help us to understand the other, we must not expect too close an agreement in the steps of their degeneration under similar conditions.

There are three cave salamanders in North America.

1. *Spelerpes maculicauda* is found generally distributed in the caves of the Mississippi valley. It so closely resembles *Spelerpes longicauda* that it has not until more recent years been distinguished from the latter which has an even wider epigæan distribution. There is nothing about the structure of this salamander that marks it as a cave species but its habits are conclusive.

2. *Typhlotriton* is much more restricted in its distribution, being confined to a few caves in southwestern Missouri. I have taken its larvæ at the mouth of Rock House cave in abundance. In the deeper recesses of Marble cave I secured both young and adult. This is a cave species of a more pronounced type. The very habit that accounts for the presence of salamanders in caves has been retained by this one. I found some individuals hiding (?), under rocks and in the aquarium their steriotropic nature manifests itself by the fact that they crawl into glass tubing, rubber tubing or under wire screening. In the eye of this species we have some of the early steps in the process of degeneration.

3. *Typhlomolge* has been taken from a surface well near San Marcos, Texas, and from the artesian well of the U. S. Fish Commission which taps a cave stream about 190 feet from the surface. It has also been seen in the underground stream in Ezel's cave near San Marcos. It was also reported to me from south of San Antonio, Texas. This is distinctly and exclusively a cave species and its eyes are more degenerate than those of any other salamander, including the European Proteus.*

The Amblyopsidæ are a small family of fresh water fishes and offer exceptional facilities for the study of the steps in the degeneration of eyes. There are at least six species and we have gradations in habits from permanent epigæan species to species that have for ages been established in caves.

The species of *Chologaster* possess well developed eyes. One of them, *C. cornutus*, is found in the coast streams of the southeastern States; another, *C. papilliferus*, is found in some springs in southwestern Illinois, while the third, *C. agassizii* lives in the cave streams of Kentucky and Tennessee.

The other members of the family are cave species with very degenerate eyes. They represent three genera which are descended from three epigæan species. *Amblyopsis*, the giant of the race, which reaches 135

*It may be noticed that the eyes of the western *Typhlotriton* are more degenerate than those of the cave *Spelerpes* of wider distribution. Further the eyes of the Texan *Typhlomolge* are more degenerate than those of the Missouri *Typhlotriton*. Now similarly the Missouri blind fish *Troglichthys* has eyes in a much more advanced state of degeneration than the Ohio valley blind fishes. It is possible that the explanation is to be found in the length of time the caves in these regions have been habitable. During the glacial epoch the caves of the Ohio valley were at or near the northern limit of vegetation. The Missouri caves, if affected by glaciation, must have become habitable before those of the Ohio valley, while those of Texas were probably not affected at all.

mm. in length, is found in the caves of the Ohio Valley. *Typhlichthys* is also found in the Ohio Valley but chiefly south of the Ohio river. But a single specimen has been found north of the Ohio and this represents a distinct species. *Troglichthys* which is found in the caves of Missouri, has been in caves longer than its relatives if the degree of degeneration of its eyes is a criterion.

Before dealing with the degeneration of the eye a few words are in order on the normal structure of the organ under consideration.

In the normally developed eye we may distinguish a variety of parts with different functions. These are:

A. Organs for protection like the lid and orbits.

B. Organs for moving the eye to enable it to receive direct rays of light. In the cold-blooded vertebrates these consist of four rectus muscles and two oblique.

C. Organs to support the active structures, the fibrous or cartilaginous sclera.

D. The eye itself consisting of:

1. Parts for transmitting and focusing light; the cornea, lens and vitreous body.

2. Parts for receiving light and transforming it to be transmitted to the brain; the retina.

3. A part for transmitting the converted impression to the brain; the optic nerve.

Some of these as the muscles, retina and optic nerve are active while others, the protective and supporting organs, are passive.

A. In the Amblyopsidæ the skin passes directly over the eye without forming a free orbital rim or lid. The skin over the eye in *Chologaster* is much thinner than elsewhere and free from pigment. In the other species of the family the eye has been withdrawn from the surface. In these it lies deep beneath the skin and the latter where it passes over the eye, has assumed the structure normal to it in other parts of the head.

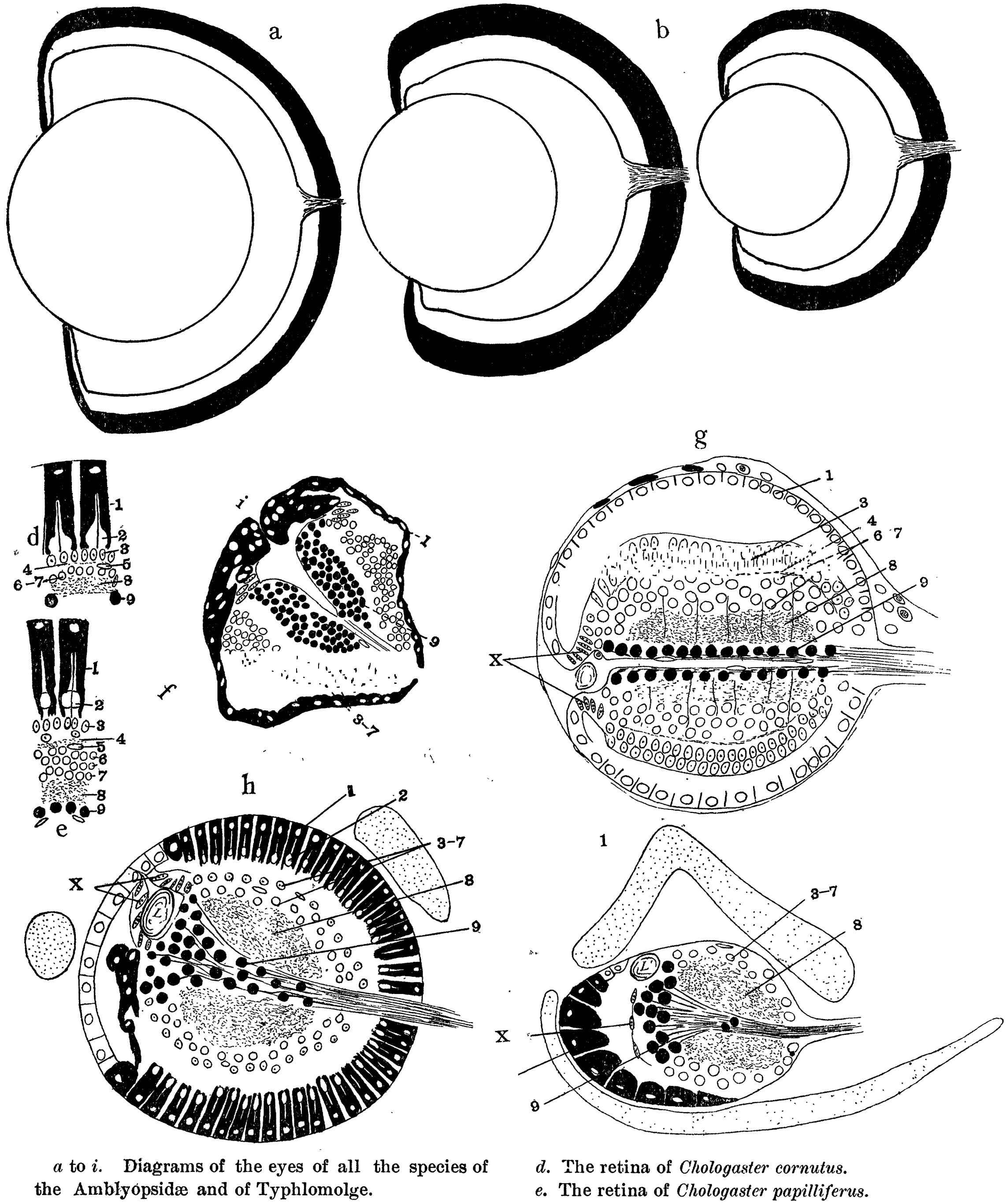
In the salamanders we have a perfect gradation in the matter of the eye-lids. In *Spelerpes* a free orbital rim is present in every respect like that found in epigæan salamanders. In *Typhlotriton* the lids are closing over the eye. The slit between the upper and lower lid is much shorter than normally and the upper lid overlaps the lower. The conjunctiva is still normal. The eye of this species is midway between the normal salamander eye and that of *Typhlomolge*, in which a slight thinning of the skin is all there is to indicate its former modification over the eye.

B. The muscles to change the direction of the eye-ball show complete gradations from perfect development to total disappearance.

In the species of *Chologaster* all the muscles are normally developed. In *Amblyopsis* the muscles are unequally developed, but one or more are always present and can be traced from their origin to the eye. In *Troglichthys*, the distal halves of the muscles, the parts nearest the eye have been replaced by connective tissue fibers, *i. e.*, a tendon has replaced part of the muscle. Here we have a step in advance in the degeneration found in *Amblyopsis* and no instance was noticed where *all* the muscles of any eye were even developed in the degree described. In *Typhlichthys* the muscles have all disappeared.

In *Typhlomolge* the muscles have disappeared; in the other salamanders they are present.

C. The sclera is differently developed in *Chologaster*, and there is but little modification in the species with more degenerate eyes except that in *Amblyopsis* and *Troglichthys*, where cartilaginous bands were evidently present in the epigæan ancestors. These bands have persisted in a remarkable degree, being much too large for the minute eyes with which they are connected. In *Troglichthys* they form a hood over the front




*a* to *i*. Diagrams of the eyes of all the species of the Amblyopsidæ and of Typhlomolge.

*a* to *c* are the eyes of *Chologaster cornutus*, *papilliferus* and *agassizii* drawn to scale.

*d*, *e*, *g*, *h* and *i* are drawn under the same magnification.

*d*. The retina of *Chologaster cornutus*.

*e*. The retina of *Chologaster papilliferus*.

*f*. The eye of *Typhlomolge* under lower magnification.

*g*. The eye of *Typhlichthys subterraneus*.

*h*. The eye of *Amblyopsis spelæus*.

*i*. The eye of *Troglichthys rosæ*.

of the eye, and various projections and angles in their endeavor to accommodate themselves to the small structure which they cover.

This is in striking contrast to the conditions in *Typhlotriton*, where but a slight nodule of cartilage remains and this is very frequently absent in the adult, while in the larva of the same species a cartilaginous band extends almost around the equator of the eye. The different effect of degeneration in the Amblyopsidæ and the salamanders could not be more forcibly illustrated than by the scleral cartilages.*

D. The eye as a whole and its different parts may now be considered.

1. The dioptric apparatus.

The steps in degeneration of the eye in general are indicated in the accompanying figure.

The most highly developed eye is that of *Chologaster papilliferus*. The parts of this eye are well proportioned, but the eye as a whole is small, measuring less than one millimeter in a specimen 55 mm. long. The proportions of this eye are symmetrically reduced if it has been derived from a fish eye of the average size, but the retina is much simpler than in such related pelagic species as *Zygonectes*. The simplifications in the retina have taken place between the outer nuclear and the ganglionic layers. The pigment layer has not been materially affected. These facts are exactly opposed to the supposition of Kohl that the retina and the optic nerve are the last to be affected and that the vitreous body and the lens cease to develop early. In *Chologaster papilliferus* the latter parts are normal, while the retina is simplified. That the retina is affected first is proved beyond cavil by *Chologaster cornutus*. The vitreous body and the lens are here larger than *papilliferus*, but the retina is very greatly simplified. *Cornutus*, it must be borne in mind, lives in the open. The eye of the cave species *Chologaster agassizii* differs from that of *papilliferus* largely in size. There is little difference in the retinas except the pigmented layer, which is about 26 per cent. thinner in *agassizii* than in *papilliferus*.

There is a big gap between the lowest eye of *Chologaster* and the highest eye of the blind members of the Amblyopsidæ. The lens in the latter has lost its fibrous nature and is merely an ill-defined minute clump of cells scarcely distinguishable in the majority of cases. The vitreous body of the latter species is gone with perhaps a trace still remaining in *Typhlichthys*. With the loss of the lens and the vitreous body the eye collapsed so that the ganglionic layer formerly lining the vitreous cavity has been brought together in the center of the eye.

The layers of the retina in *Typhlichthys* are so well developed that could the vitreous body and lens be added to this eye it would stand on a higher plane than that of *Chologaster cornutus*, exclusive of the cones and pigmented layer. It is generally true that at first the thickness of the layers of the retina is increased as the result of the reduction of the lens and vitreous body and the consequent crowding of the cells of the retina whose reduction in number does not keep pace with the reduction in the dioptric apparatus in total darkness.

If we bear in mind that no two of the eyes represented here are members of a phyletic series, we may be permitted to state that from an eye like that of *cornutus*, but possessing scleral cartilages, both the eyes of *Amblyopsis*, and *Troglichthys* have been derived and that the eye of *Amblyopsis* represents one of the stages through which the eye of *Troglichthys* passed. The eye of *Amblyopsis* is the eye of *C. cornutus* minus a vitreous body with the pupil closed and with a minute lens or none at all. The nuclear

* The presence of a cartilaginous band in the young is, possibly, a larval character, and its absence in the adult has, in that case, no bearing on degeneration.

layers have gone a step further in their degeneration than in *cornutus*, but the greatest modification has taken place in the dioptric arrangements.

In *Troglichthys* even the mass of ganglionic cells present in the center of the eye as the result of the collapsing after the removal of the vitreous body has vanished. The pigmented epithelium, and, in fact, all the other layers, are represented by mere fragments.

The eye of *Typhlichthys* has degenerated along a different line. There is an almost total loss of the lens and vitreous body in an eye like that of *papilliferus* without an intervening stage like that of *cornutus*, and the pigment layer has lost its pigment, whereas in *Amblyopsis* it was retained.

The salamanders bridge the gap existing between the *Chologasters* and the blind members of the Amblyopsidæ. But even at the risk of monotonous repetition I want again to call attention to the fact that the salamanders do not belong to the same series as the Amblyopsidæ. The dioptric arrangements of *Typhlotriton* are all normal, the retina is normal in the young, but the rods and cones all disappear with the change from the larval to the adult condition. In *Typhlomolge*, the lens and largely the vitreous body are gone and the eye has collapsed. The vitreous body is, however, much better represented than in the blind Amblyopsidæ and the iris is, especially in the young, much better developed than in the fishes.

2. The retina.

(*a*) There is more variety in the degree of development of the pigment epithelium than in any other structure of the eye. Ritter has found that in *Typhlogobius* this "layer has actually increased in thickness concomitantly with the retardation in the development of the eye, or it is quite possible with the degeneration of this particular part of it. An increase of pigment is an incident to the gradual diminution in functional importance and structural completeness." There is so much variation in the thickness of this layer in various fishes that not much stress can be laid on the absolute or relative thickness of the pigment in any one species as an index of degeneration. While the pigment layer is relative to the rest of the retina, very thick in the species of *Chologaster* it is found that the pigment layer of *Chologaster* is actually not much, if any, thicker than that of *Zygonectes*; exception must be made for specimens of the extreme size in *papilliferus* and *agassizii*. In other words, primarily the pigment layer has retained its normal condition while the rest of the retina has been simplified and there may even be an increase in the thickness of the layer as one of its ontogenic modifications. Whether the greater thickness of the pigment in the old *Chologaster* is due to degeneration or the greater length of the cones in a twilight species, I am unable to say. In *Typhlichthys*, which is undoubtedly derived from a *Chologaster*-like ancestor, no pigment is developed. The layer retains its epithelial nature and remains apparently in its embryonic condition. It may be well to call attention here to the fact that the cones are very sparingly developed, if at all, in this species. In *Amblyopsis*, in which the degeneration of the retina has gone further but in which the cones are still well developed, the pigment layer is very highly developed, but not by any means uniformly so in different individuals. The pigment layer reaches its greatest point of reduction in *rosæ* where pigment is still developed, but the layer is fragmentary except over the distal part of the eye. We thus find a development of pigment with an imperfect layer in one case (*Troglichthys*) and a full developed layer without pigment in another (*Typhlichthys*). In the *Chologasters* the pigment is in part prismatic; in the other species granular.

(*b*) In the outer nuclear layer a complete series of steps is observable from the two-layered condition in *papilliferus* to the one-layered in *cornutus*, to the undefined layer in *Typhlichthys* and the merging of the nuclear in *Amblyopsis*, and their occasional total absence in *Troglichthys*. The rods disappear first, the cones long before their nuclei.

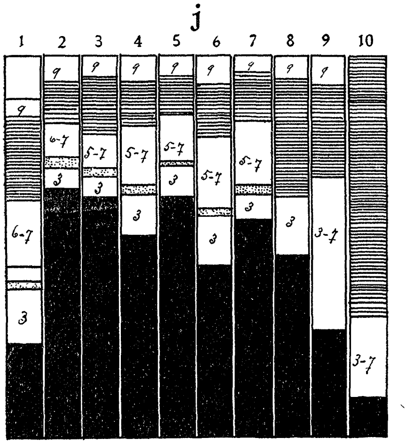



Diagram showing the per cents. of the total thickness of each of the layers of the retina in 1. *Zygonectes notatus*. 2. *Chologaster cornutus* 27 mm. long. 3. 43 mm. long. 4. *Chologaster papilliferus* 29–39 mm. and 5., 55 mm. long. 6. *Chologaster agassizii* 38 mm. long and 7., 62 mm. long. 8. *Amblyopsis*. 9. *Typhlichthys*. 10. *Troglichthys*.

(*c*) The outer reticular layer naturally meets with the same fate as the outer nuclear layer. It is well developed in *papilliferus*, evident in *C. cornutus*, developed in spots in *Typhlichthys*, and no longer distinguishable in other species.

(*d*) The layers of horizontal cells are represented in *papilliferus* by occasional cells; they are rarer in *cornutus* and beyond these have not been detected.

(*e*) The inner nuclear layer of bipolar and spongioblastic cells is well developed in *papilliferus*. In *cornutus* it is better developed in the young than in the older stages where it forms but a single layer of cells. There is evidently in this species an ontogenic simplification. In the remaining species it is, as mentioned above, merged with the outer nuclear layer into one layer which is occasionally absent in *Troglichthys*.

(*f*) The inner reticular layer is relatively better developed than any of the other layers and the conclusion naturally forces itself upon one that it must contain other elements besides fibers of the bipolar and ganglionic cells, for, in *Amblyopsis* and *Troglichthys*, where the latter are very limited or absent, this layer is still well developed. Horizontal cells in this layer have only been found in the species of *Chologaster*.

(*g*) In the ganglionic layer we find again a complete series of steps from the most perfect eye to the condition found in *Troglichthys*. In *papilliferus* the cells form a complete layer one cell deep except where the cells have given way to the optic fiber tracts which pass in among the cells instead of over them. In *cornutus* the cells have been so reduced in number that they are widely separated from each other. With the loss of the vitreous cavity the cells have been brought together again into a continuous layer in *Typhlichthys*, although there are much fewer cells than in *cornutus* even. The next step is the formation of a solid core of ganglionic cells and the final step the elimination of this central core in *Troglichthys*, leaving but a few cells over the anterior face of the retina.

(*h*) Müllerian nuclei are found in all but *Troglichthys*. In *C. cornutus* they lie in part in the inner reticular and the ganglionic layer. Cells of this sort are probably also found among the ganglionic cells of *Typhlichthys*.

3. The optic nerve shows a clear gradation from one end of the series of fishes to the other. In *Chologaster papilliferus* it reaches its maximum development. In *cornutus* which possesses an eye larger than *papilliferus*, but in which the ganglionic

layer is simplified, the nerve is measurably thinner. In *Typhlichthys* the nerve can be traced to the brain in specimens 40 mm. long, *i. e.*, in specimens which are evidently adult. In *Amblyopsis* the nerve can be followed to the brain in specimens 25 mm. long, but in the adult I have never been able to follow it to the brain. In *Troglichthys* it has become so intangible that I have not been able to trace it far beyond the eye.

We thus see that the simplification or reduction in the eye is not a horizontal process. The purely supporting structures like the scleral cartilages have been retained out of all proportion to the rest of the eye. The pigment layer has been both quantitatively and qualitatively differently affected in different species. There was primarily an increase in the thickness of this layer and later a tendency to total loss of pigment. The degeneration has been more uniformly progressive in all the layers within the pigment layer. The only possible exception being the inner recticular layer which probably owes its retention more to its supporting than to its nervous elements. Another exception is found in the cones, but their degree of development is evidently associated with the degree of development of the pigmented layer. As long as the cones are developed the pigmented layer is well developed or *vice versa.*

We find in general then that the reduction in size from the normal fish eye went hand in hand with the simplification of the retina. There was at first chiefly a reduction in the number of many times duplicated parts. Even after the condition in *Chologaster papilliferus* was reached, the degeneration in the histological condition of the elements did not keep pace with the reduction in number (*vide*, the eye of *cornutus*). The dioptric apparatus disappeared rather suddenly and the eye as a consequence, collapsed with equal suddenness in those members which, long ago, took up their abode in total darkness. The eye not only collapsed, but the number of elements decreased very much. The reduction was in the horizontally repeated elements. The vertical complexity, on which the function of the retina really depends, was not greatly modified at first.

In those species which took up their abode in total darkness the degeneration in the dioptric apparatus was out of proportion to the degeneration of the retina, while in those remaining above ground the retinal structures degenerated out of proportion to the changes in the dioptric apparatus, which, according to this view degenerates only under conditions of total disuse or total darkness which would necessitate total disuse. This view is upheld by the conditions found in *Typholgobius*, as Ritter's drawings and my own preparations show. In *Typholgobius* the eye is functional in the young and remains a light perceiving organ throughout life. The fish live under rocks between tide water (Eigenmann, 90). We have here an eye in a condition of partial use and the lens is not affected. The retina has, on the other hand, been horizontally reduced much more than in the Amblyopsidæ, so that should the lens disappear, and Ritter found one specimen in which it was gone, the type of eye found in *Troglichthys* would be reached without passing through a stage found in *Amblyopsis*, it would be simply a horizontal contracting of the retina, not a collapsing of the entire eye.

The question may with propriety be asked here, do these most degenerate eyes approach the condition of the pineal eye? It must be answered negatively.*

* The degree of degeneration reached in the eye of *Troglichthys* which began to degenerate comparatively recently would lead one to expect the pineal eye to be much more degenerate than it is actually found to be in the lizards unless its functions were something aside from light perception.

Ontogenic degeneration.

The simplification of the eye in *cornutus* with age has been mentioned in the foregoing paragraphs. The nuclear layers are thinner in the old than in the young. There is here not so much an elimination or destruction of elements as a simplification of the arrangements of parts, comparatively few being present to start with.

The steps in ontogenic degeneration can not yet be given with any degree of finality for *Amblyopsis* on account of the great variability of the eye in the adult. While the eyes of the very old have unquestionably degenerated, there is no means of determining what the exact condition of a given eye was at its prime. In the largest individual examined the eye was on one side a mere jumble of scarcely distinguishable cells, the pigment cells and scleral cartilages being the only things that would permit its recognition as an eye. On the other side, the degree of development was better. The scleral cartilages are not affected by the degenerative processes and are the only structures that are not. The fact that the eyes are undergoing ontogenic degeneration may be taken, as suggested by Kohl, that these eyes have not yet reached a condition of equilibrium with their environment or the demands made upon them by use. Furthermore, the result of the ontogenic degeneration is a type of structure below anything found in phylogeny. It is not so much a reduction of the individual parts as it is a wiping out of all parts.

PLAN AND PROCESS OF PHYLETIC DEGENERATION.

Does degeneration follow the reverse order of development, or does it follow new lines, and if so, what determines these lines?

Before discussing this point I should like to call attention to some of the processes of ontogenic development concerned in the development of the eye. There are three processes that are of importance in this connection: 1. The multiplication of cells. 2. The arrangement of cells including all the processes leading to morphogenesis. Frequently the first process continues after the second one has been in operation. 3. Lastly we have the growth and modification of the cells in their respective places to adapt them to the particular function they are to subserve—histogenesis.

Since the ontogenetic development of the eye is supposed to follow in general lines its phylogenetic development the question resolves itself into whether or not the eye is arrested at a certain stage of its development and whether this causes certain organs to be cut off from development altogether. In this sense the question has been answered in the affirmative by Kohl. Ritter, while unable to come to a definite conclusion, notes the fact that in one individual of *Typhlogobius* the lens, which is phylogenetically a new structure, had disappeared. But this lens had probably been removed as the result of degeneration rather than through the lack of development.

Kohl supposes that in animals placed in a condition where light was shut off, more or less, some of the developmental processes are retarded. In successive generations earlier and earlier processes in the development of the eye are retarded and finally brought to a standstill; thus every succeeding generation developed the eye less. Total absence of light must finally prevent the entire *anlage* of the eye, but time, he thinks, has not been long enough to accomplish this in any vertebrate. The cessation of development does not take place at the same time in all parts of the eye. The less important, those parts not essential to the perception of light, are disturbed first. The retina and the optic nerve are the least affected, the iris comes next in the series. Because the cornea, aqueous and vitreous bodies and the lens are not essential for the performance of the function of the eye, these structures cease to develop early. The processes of degeneration follow the same rate. Degeneration is brought about by the falling apart of the elements as the result of the introduction of connective tissue cells that act as wedges. Abnormal degeneration sometimes becomes manifest through the cessation of the reduction of parts that normally decrease in size (p. 269), so that these parts in the degenerate organ are unusually large.

Kohl's theoretical explanation is based on the study of an extensive series of degenerate eyes. He has not been able to test the theory in a series of animals actually living in the condition he supposes for them, and has permitted his erroneous interpretation of the highly degenerate eye of *Troglichthys* to lead him to the theory of the arresting of the eye in ever-earlier stages of ontogeny. The eye of *Troglichthys* is in an entirely different condition from that supposed by him. The mere checking of the normal morphogenic development has done absolutely nothing to bring about this condition and it could not have been produced by the checking of development in ever earlier and earlier stages of ontogeny, for there is no stage in normal ontogeny resembling in the remotest degree the eye of the adult *Troglichthys*. The process of degeneration as seen in the Amblyopsidæ is in the first instance one of growing smaller and simpler (not more primitive) in the light —not a cutting off of late stages in the development in the dark. The simplified condition, it is true, appears earlier and earlier in ontogeny till it appears along the entire line of development, even in the earliest stages. This simplified condition never gives any evidence of being more primitive; it is simply less elaborate. The tendency for characters added or modified at the end of ontogeny to appear earlier and earlier in the ontogeny is well known, and there is no inherent reason why an organ disappearing in the adult should not eventually disappear entirely from ontogeny. The fact that organs which have disappeared in the adult, have in many instances not also disappeared in the ontogeny and remain as so-called rudimentary organs has received an explanation from Sedgwick. In his re-examination of the biogenetic law he came to the conclusion that "the only functionless ancestral structures, which are present in development, are those which at some time or another have been of use to the organism during its development after they have ceased to be so in the adult." The length of time in such cases since the disuse of such an organ in the young is much shorter than that since its use in the adult. All organs functionless in the adult, but functional in the early ontogeny, develop in the normal way. Organs no longer functional at any time dwindle all along the line of development. In *Typhlogobius*, where the eye is functional in the young, it develops to full size in the embryo and it is not till late in life that degeneration is noticeable. In *Amblyopsis* on the other hand, where the eye has not been functional at any period of ontogeny for many generations where the eye of both the young and adult lost their function on entering the caves, and where degeneration begins at an early period and continues till death, the degenerate condition has reached the early stages of the embryo. It is only during the first few hours that the eye gives promise of becoming anything more than it eventually does become. The degree of degeneration of an organ can be measured as readily by the stage in ontogeny when the degeneration becomes noticeable as by the structure in the adult. The greater the degeneration the further back in the ontogeny the degenerate condition becomes apparent unless, as stated above, the organ is of use at some time in ontogeny. It is evident that an organ in the process of being perfected by

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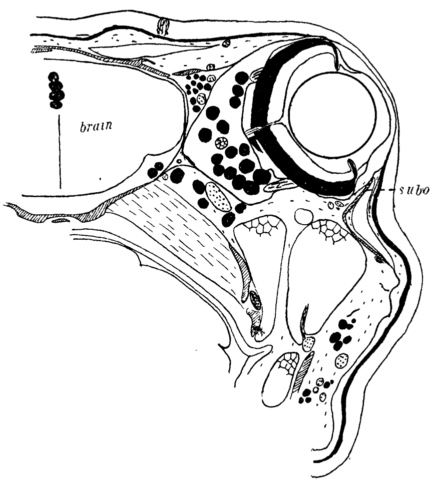


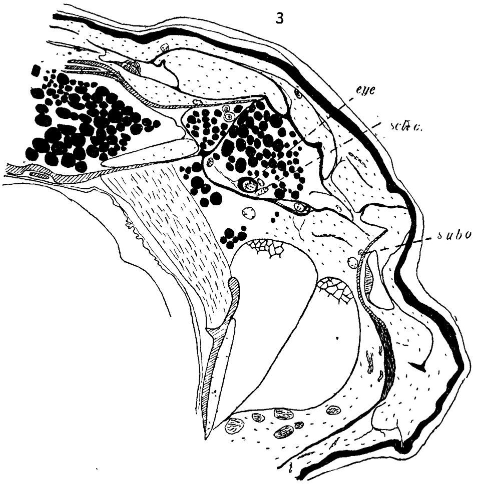


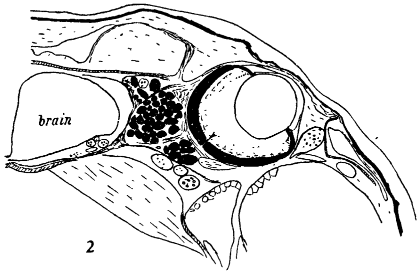


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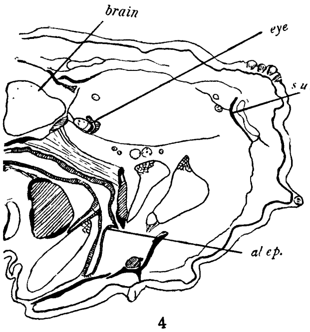


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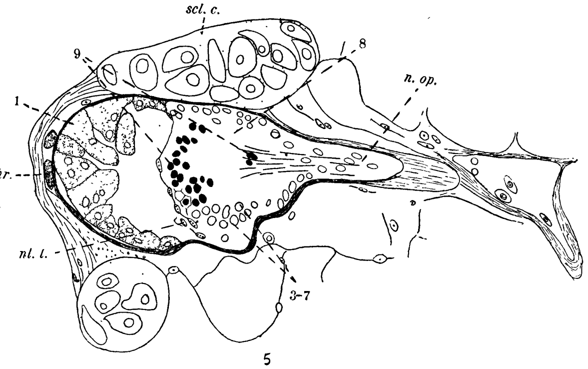


5

1. Part of the section of the head of *Chologaster papilliferus* at the optic nerve ; subo.-suborbital.

2. Part of the section of the head of *Chologaster agassizii.*

3. Part of the section of the head of an *Amblyopsis* showing the location of the eye ; subo.-suborbital. scl., scleral-cartilage.

4. Part of the section of the head of *Troglichthys* passing through the eye ; al. ep., alimentary epithelium.

5. The most degenerate vertebrate eye known, that of *Troglichthys* in vertical section. 1, pigment layer of the retina ; 3–7, retina from the pigmented layer to the inner reticular layer; 8, inner reticular layer; 9, ganglionic layer; n. op., optic nerve; nl. l., nuclei of the hyaloid; chr. choroid pigment; scl. c., scleral cartilages.

selection may be crowded into the early stages of ontogeny by post selection. Evidently the degenerate condition is not crowded back for the same reason. How it is crowded back I am unable to say. A satisfactory explanation of this will also be a satisfactory explanation of the process by which individually acquired characteristics are enabled to appear in the next generation. The facts, which are patent, have been formulated by Hyatt in his law of tachygenesis.

Cessation of development takes place only in so far as the number of cells are concerned. The number of cell generations produced being continually smaller, result in an organ as a consequence also smaller. In this sense we have a cessation of development (cell division, not morphogenic development) in ever earlier stages. That there is an actual retardation of development is evident from *Amblyopsis* and *Typhlichthys* in which the eye has not reached its final form when the fish are 25 mm. long.

Histogenic development is a prolonged process and ontogenic degeneration is still operative at least in *Amblyopsis*.

Degeneration in the individual is not the result of the ingrowth of connective tissue cells as far as I can determine. It is rather a process of starving, or shriveling and resorption of parts.

From the foregoing it is evident that degeneration has not proceeded in the reverse order of development, rather the older normal stages of ontogenic development have been modified into the more recent phyletic stages through which the eye has passed. The adult degenerate eye is not an arrested ontogenic stage of development but a new adaptation and there is an attempt in ontogeny to reach the degenerate adult condition in the most direct way possible.

CARL H. EIGENMANN.

## *SCIENTIFIC BOOKS.*

*The Ore Deposits of the United States and Canada.* By JAMES FURMAN KEMP. Third Edition entirely rewritten and enlarged. New York and London, The Scientific Publishing Company. 1900.

The first edition of 'Kemp's Ore Deposits of the United States' appeared in 1893. The second edition from the same plates, in which forty to fifty pages of additional matter had been inserted, was published in 1895. We now have the third edition, with entirely new plates, which forms a volume nearly twice as thick as the first, with larger type, heavier paper and additional plates which contribute, as well as the new matter, to its increased size. As this is practically the only modern work dealing in any adequate fashion with this important subject, and as it hence constitutes the standard work for reference with regard to the ore deposits of the United States and Canada, it is important to consider its shortcomings as well as its merits, and even to dwell upon the former.

It must be evident to all who consult the work that Professor Kemp has been remarkably thorough in his search of the literature of his subject and few books have a more complete bibliography; the references, moreover, are distributed throughout the text, not lumped together at the end, so that it requires very little labor on the part of the reader to go back to original authorities on any given point. Kemp possesses, moreover, in a high degree the important faculty of reading intelligently and of expressing concisely the leading facts gathered in the course of his reading. This is perhaps the most important qualification for a work that is essentially a compilation rather than an original treatise.

For a philosophical treatment of phenomena like ore deposits, in which different observers may in all honesty draw diametrically different conclusions from their respective examinations of the same deposit, it is essential that the author should have been able by personal inspection to verify the relative accuracy or degree of probability of opposing views; for in this case, even if we may differ with the author's theoretical opinions, we know that the coeffi-