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ON THE STRUCTURE OF THE RETINA.

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The following is an abstract of a paper sent to the Editors of this Journal, in which we endeavoured to connect the results of our observations with those of observers during the last few years. We refer especially to the memoirs of Landolt, Krause, Golgi and Manfredi, and Schwalbe, and also to the views of Heinrich Müller, Kölliker, and Max Schultze. Further, in consideration of the number of new points raised and the divergence of some of our views from those generally taught, we deemed it advisable to explain in detail the methods employed during the investigation. The result of this was that, notwithstanding our attempt to be concise, the paper assumed such dimensions that the Editors returned it with a request that it should be shortened. To meet their desire we have omitted all reference to technical details and methods, and stated our conclusions with as much brevity as is consistent with clearness, and have almost entirely abstained from allusions to other writers. This we have done with great regret.

Our position in regard to other investigators will become evident if our remarks are read in connection with the resumé given by Schwalbe in his valuable article on the retina in the Handbuch lately published under the editorship of von Graefe and Saemisch.

To fellow-workers we will gladly communicate any information desired concerning the methods employed, or regarding any matter briefly touched on in the text.

The nomenclature used throughout this paper is from within outwards, as follows; 1. Membrana limitans interna. 2. Layer of optic nerve fibres. 3. Layer of Ganglion cells. 4. Molecular layer. 5. Internal granule layer. 6. Intergranule layer. 7. External granule layer. 8. Membrana limitans externa. 9. Bacillary layer. 10. Layer of pigment epithelium.

Before examining these layers it will be well to begin with a description of the radial fibres (*Radial-fasern* of H. Müller).

In the frog's retina, these when examined in glycerine after staining the whole retina in a solution of purpurine, appeared, in the first place, as flattened cylindrical bands faintly fibrillated on their surface, with even contoured borders, and one or more nuclei adhering to them at different points. These correspond to the radial fibre figured by Schwalbe. In the

next place they may be seen, as described by Müller and Kölliker, to consist of well-defined fibres generally enclosing nuclei as they pass through the internal granule layer. On careful examination the fine fibre of Müller and Kölliker may be often found enveloped by the flattened cylindrical band of Schwalbe, Figs. 2 and 3. Hence this band forms a loose investing sheath for the true fibre. The extent to which the fibre is enveloped by membranous substance depends on the mode of preparation and produces a great variety of appearances. Frequently the fibre has been quite freed from membrane except at the inner end. When this is the case the remnant of membrane left forms the well-known trumpet-shaped end of a fibre (*Radialfaserkegel*) described and figured by Schwalbe and Müller.

The nucleus of the fibre, Fig. 2 *b*, is apt to be mistaken for nuclei lying on, but not in, the fibre. It lies in a lozenge-shaped swelling, and is best seen in purpurine preparations stained with log-wood. Differing from the narrow elliptical nucleus in the fibre are other nuclei adhering to the membranous sheath of the fibre. These nuclei are either large and oval, and correspond to one of the so-called granules, Fig. 3 *e*; or are small and round, and belong to elongated cells lying on the membrane, one of which from a purpurine preparation is figured at 1 *d*.

Differing from the authorities already referred to, we have found the true radial fibres of the frog's retina extending beyond the external limiting membrane, to the outer segments of the rods.

We will now describe the different layers.

The membrana limitans interna.—This Kölliker considers an independent membrane: but Schwalbe and Schultze believe it to be "a piece of the hyaloid membrane to which radial fibres have adhered." In papers previously published by one of us[1], the membrana limitans interna is described as distinct from the hyaloid and as covered with a layer of epithelial cells. Of the existence of this membrane and its layer of cells we have obtained further evidence during the present investigation. Fig. 8 shows part of an extensive layer of cells from the retina of a sheep preserved in carbolized serum. The cells,

[1] *Journal of Anatomy and Physiology*, May and November, 1874.

mostly hexagonal, were seen, on regulating the focus, to form a double layer over a considerable part of the surface, and under them the optic nerve and ganglionic cells were distinctly seen. The difference between these hexagonal cells and the silver markings that indicate the ends of the radial fibres is well brought out by comparing Fig. 8 with Fig. 9.

In the frog we have demonstrated the cells and the membrane on which they lie both with gold and osmic acid, and we have seen external to the membrane the network of blood-vessels. The hexagonal form of the cells is imperfectly shewn in Fig. 6, a silver preparation in which the intercellular substance alone is stained. Immediately external to this layer of cells, we find in silver preparations, the fields indicated in Fig. 7, the so-called terminal swellings of the radial fibres. When a perfectly macerated fibre is examined, the main stem is seen to split up into minute terminal fibres as soon as it becomes internal to the molecular layer; and when these fibres are completely invested by a membranous expansion, we have formed the trumpet-shaped structure (*Faser-kegel*) already referred to and indicated in Fig. 7. Besides the fibres, and the membranous investment, which may be more or less complete, a varying number of nuclei are found, the position of which is indicated in Figs. 3 and 4. From the regularity of the fields in the frog's retina, and from the position of some of the nuclei across the mouth of the trumpet-shaped expansion, Fig. 4 *b*, we might infer that the spaces correspond to a layer of cells. It is different, however, in the sheep's retina, in which the irregular fields evidently do not correspond to cell-outlines, but to the subdivisions and anastomoses of the radial fibres in a membranous substance from which the cells have disappeared. In the sheep's retina the silver lines indicated at Fig. 9 are arranged after a plan that we have not seen noticed. The surface is seen to be divided by dark parallel lines equidistant from each other, and the fields in one division never cross the line into another.

In our remarks on the layer of *optic nerve-fibres* we pass over the consideration of that part of it undoubtedly nervous in its nature: and only notice what we believe to be, most probably, connective tissue.

In our preparations we found delicate fibrillary bundles, the fibrils of which had no varicosities, were very slightly stained, and had no characteristic nervous structure. We also found among the fibrillary bundles an abundant reticulum of colourless delicate fibres, contrasting markedly with these.

In addition, we observed many elongated narrow cells applied to the surface of the smaller bundles. These were found to be of a fixed and definite type; but their number varied in different preparations, Fig. 11. Indeed from the large number of nuclei seen, we feel sure that only a small proportion of these cells was shown. We may finally say, on this point, that nuclei of a larger size were also seen, most probably nuclei of cells differing from those already described. By our present modes of preparation we are unable to determine whether these cells completely invest the bundles or not. They may, however, be identical with those cells occasionally found, in teased preparations, adhering to the inner ends of the radial fibres.

Ganglionic cell-layer. — In regard to this layer we have nothing new to add to what has been already observed.

Molecular layer.—Both on the external and internal surfaces of this layer we found small round cells investing it like an epithelium. Those investing the inner surface have a round nucleus with only a small amount of cell-matter, Fig. 12, while those covering the outer have a larger nucleus and a moderate amount of cell-substance, Fig. 13.

The ground-substance of this layer was found to be made up of a number of parallel cylindrical elements of uniform size, and with a diameter equal to that of a human red blood-corpuscle. Amongst these elements nuclei could be detected, Figs. 15 and 16. Lying on these cylinders and investing them, we detected cellular elements: but whether these were cells or only cell-nuclei, we have not as yet been able to decide. They are, however, almost exact counterparts of the cells already described by us as investing the primary fibres of the lens[1].

In vertical sections we found in the frog a division into seven or eight layers, separated from each other by clear spaces, Fig. 5. In one very successful preparation where the mole-

[1] Vide this *Journal*, Vol. x. p. 226, woodcut III.

cular layer with its outer investing cells was isolated, we noticed a decided longitudinal grooving.

Internal granule-layer.—We may regard this layer as made up of small rounded cells, arranged like an epithelium; of radial fibres with their nuclei; of small spindle cells and of narrow flat cells, sometimes adhering to the membranous substance connecting the radial fibres. The flat cells, Fig. 18, we have been able to observe in the frog, *in situ*, in at least three layers, parallel to the surface of the retina. In these cases the radial fibres have been dissolved, so that the cells are seen in their natural position. We have also noticed these cells entangled in the delicate fibrils given off from the radial fibres.

The spindle cells mentioned, Fig. 19, most probably lie in a direction perpendicular to the retina, as when isolated by teasing they are generally parallel to the radial fibres. We have been unable to distinguish the bipolar ganglionic cells of Schultze and Schwalbe. What they describe as such are most probably referable either to the spindle cells or entangled flat cells we have already spoken of.

Intergranule-layer.—The existence of flattened cells in this layer of the retina of several fishes is well known. In the frog we have found numerous large flat oval nuclei, lying parallel to the surface of the retina, Fig. 21, and sometimes arranged in a double layer. With gold and formic acid[1] we have isolated a membranous substance on which the nuclei probably lie. To this membranous substance portions of what we shall presently describe as the rod-pedicles often remain attached, Fig. 21. Besides the membrane and nuclei, which probably are closely related to it, in osmic acid preparations long macerated in glycerine, numerous delicate true fibres are found in this layer. Many of them are in direct continuity with the radial fibres. The main stem of the radial fibre passes through at right angles, but as it enters gives off a number of minute branches, which ramify in this layer. We believe that all the fibres in this layer have their origin from the radial fibres; thus agreeing with Schultze and Landolt.

In a frog's retina, treated with gold and then macerated for

[1] The method employed was essentially that described by Löwit in the *Wien. Akad. Sitz.-Bericht*, LXXI. Band.

eight days in formic acid, the external limiting membrane and the intergranule-layer were seen in section as even homogeneous vitreous looking bands. This appearance is indicated in Fig. 20. The evenness of the margins of these bands, together with the fact that they were neither composed of cells nor fibres, indicates the existence of true membranes. Further, the homogeneous band occupying the position of the intergranule-layer had like the other a double border—one border in intimate contact with the external and the other with the internal granule-layer. Hence, on the above facts, and on what is known to exist in fishes, we base the following hypothesis: namely, that in the frog the intergranule-layer consists of two cellular membranes, which bound or invest the granule layers. This agrees in the main with the ideas expounded by Krause. The appearance of flat cells with processes interspersed in a network, described by Rivolta in the retina of the horse, is probably due to the reagents employed, and cannot be held as irreconcilable with the idea of a continuous layer of cells.

External granule-layer.—This we shall describe as made up of fibres, membranes, cells, and ground-substance. In some preparations the fibres and intercellular substance are alone left, forming the substratum of the *Korn* or granule. We shall, however, not employ these terms, but consider the appearance described by them as made up of membranes, nuclei, and ground-substance. These we shall now consider in detail.

The inner segment of a rod is separated by a narrow line from the base of a small conical mass. The apex of this latter, projecting inwards, is fine and pointed, and is connected with the apex of a somewhat similar cone, whose base is adjacent to the intergranule-layer. These two we shall term respectively the outer and inner pedicles of the rods. Fig. 14.

Nearer the intergranule-layer, and in the elliptical space between adjacent outer and inner rod-pedicles, there lie elliptical bodies, pointed at both extremities, the pedicles of the cones. The outer pedicles of the rods and the cone-pedicles stain very faintly with strong log-wood. In the same preparation some of the pedicles seem to be formed of a granular matter which stains decidedly with log-wood. From a careful comparison of these, it can be seen that the tinted granular

appearance does not belong to the substance proper of the pedicle, but to an investing membrane.

In preparations by ordinary methods, nuclei form a very prominent feature in this layer in the frog's retina; these are of two kinds, viz. one round or slightly oval, the other elongated, narrow, and elliptical. The rounded ones are the nuclei of cells, which lie in two parallel rows between the external limiting membrane and the intergranular layer. Fig. 22. *b*, *c*. In the same way the elliptical nuclei are the nuclei of cells, lying in like double rows between the same limits.

In one preparation the narrow elongated nuclei could be seen to lie on the finely granular substance which encloses the rod and cone-pedicles. Fig. 22. *a*. Especially in potash preparations[1] could they be seen acting as investing cells to these rod and cone-pedicles. The *Kolben*, described by Landolt as arising from the intergranule-layer in the salamander, we believe to be one of the narrow elongated cells just described.

In preparations of the retina, well macerated in glycerine, the radial fibres may be seen to unite after passing through the layer: or to bifurcate after piercing the external limiting membrane. Thus a figure somewhat like a stirrup is formed with its concavity or convexity turned outwards according to the method of formation. When the latter is the case a single fibre may proceed out from the convexity. Fig. 25.

Such of these stirrups as are formed on the outer side of the intergranule-layer form the basis of a framework for the lodgment of the cone and inner rod-pedicles. The stirrup, with its single fibre passing outwards, is therefore not a cone bifurcating, but is due to the union of radial fibres. There is no actual continuity between the radial fibres and the rods and cones, as the radial fibres lie within funnel-shaped membranes enclosing the *Körner* or pedicles. The reversed stirrups enclose the outer rod-pedicle.

All the fibres observed by us in this layer belong to the system of radial fibres. The membranes we have spoken of are seen as small films in osmic acid preparations.

[1] For details of the method see a paper on Hyaline Cartilage in the *Quarterly Journ. for Mic. Science*, January, 1876. The fresh eye is placed entire in the solution.

The external limiting membrane.—The external limiting membrane is generally described as being formed by the terminal expansion of the radial fibres. That there are fibres in it which are indistinguishable from radial fibres can be well seen in vertical sections. But besides these and the true membranous substance shown in Fig. 20. *a*, there is a continuous layer of cells in this membrane, between which nothing visible passes from without inwards except branches of the radial fibres, and portions of thin membranes connected with them. This layer of cells may be demonstrated in the frog and toad by means of purpurine and gold, and in teased preparations the cells may be seen attached to the inner ends of the inner segments of the rods.

These cells must be distinguished from the rounded nuclei of the external granular layer, often seen projecting from the inner border of isolated rods. Such nuclei are often cut across by a line apparently indicating the position of the external limiting membrane. The difference between the two nuclei is seen by a reference to Fig. 28 *b*, in which both are indicated. Further, we believe we have demonstrated these cells in the sheep's retina by means of silver and vitreous humour preparations. A vitreous humour preparation is represented in Fig. 29. In the same preparation, by slight movements of the cover-glass, the cells could be isolated and examined free in the fluid, and their position in several instances shown by some of the inner segments of the rods remaining adherent to the surface of the small isolated patches of cells.

There is no continuity between the inner segments of the rods and cones and their corresponding pedicles (*Körner*), the cells we have described completely isolating the one from the other.

The bacillary layer.—The rods of the frog's retina are divided by histologists into two segments, an outer and inner. Between these two segments we have found a round nucleated cell completely separating the one from the other. These cells can be distinguished from the *linsenförmige Körper* of Max Schultze in osmic acid and potash preparations, Figs. 30 and 31. Sometimes in potash preparations a number of the outer segments separate in a mass from the rest of the retina with a complete layer of cells attached to their inner ends. Fig. 32.

Lying at the outer end of the inner segment is the appearance described as the lens-shaped body (*linsenförmige Körper*). This body, like the outer segment, stains in osmic acid and logwood a dark bluish colour, and contrasts strongly with the rest of the inner segment, which remains almost unstained. In potash preparations the lens-shaped body is seen forming a distinct short and almost square middle segment quite as completely divided from the inner as the outer segment. It is homogeneous in structure, and resembles closely the substance of the outer segment, and like it differs from the rest of the inner segment by being more resistent.

Looked at one way, the inner segment is of an equal breadth throughout, but when it rolls over it appears as a double concave narrow band. The oval space left between the concave margins of adjacent inner segments is partly occupied by the inner segments of the cones.

By several methods we have succeeded in demonstrating cells lying on the inner segments of the rods. In purpurine preparations macerated in glycerine numerous nuclei and fine fibres are found in the position of the rods and cones, and in osmic acid and potash preparations the complete cells are occasionally found. These cells are long, narrow, and tapering towards the external limiting membrane. One of them is represented in Fig. 34. It resembles the "Kolben" described by Landolt in the external granule layer.

We have also seen nuclei on the outer segments of the rods, and agree with those histologists who believe the outer segments to be ensheathed by a membrane.

We have not seen the axial thread described by Ritter in the outer segments of the rods, but we have sometimes seen an artificial canal produced by the gold solution.

In the mouse and the rat the outer segments stain in osmic acid darker than the inner, but the difference is not so great as in the frog. The line of separation between the two is well marked, and large masses of the outer segments are easily detached.

There are probably also narrow cells on the inner segments of the cones of the retina of the frog and hen. Fig. 35 shows several nuclei seen on one cone while it revolved under the

cover-glass from a retina treated with nitrate of silver and examined in glycerine. An entire cell from a gold and formic acid preparation is represented in Fig. 35 *a*. The outer segments of the cones in the frog pass beyond the cells lying between the outer and inner segments of the rods, and thus must pass through the small openings left between the round cells already described.

When describing the radial fibres, we mentioned that they extended beyond the external limiting membrane. At the external limiting membrane two fibres may form an arch and enclose within it the cell of the external limiting membrane. From this arch or stirrup one or two fibres may pass outwards, forming part of the framework which supports the cells and membrane of the inner segments of the rods and cones. Other fibres pass straight through the membrane, and may then bifurcate. Figs. 25 and 27 represent these different appearances[1].

The pigment epithelium of the Retina.—This has been examined in the frog, sheep, and ox: and from a consideration of our preparations, we have come to a conclusion completely opposite to that of all previous observers. The pigment is, we believe, always external to the substance of the cell. Figs, 36, 37, and 38. The grounds for this belief are as follows.

By manipulation, the pigment may be removed as a continuous layer from one part, so that we can obtain cells free from pigment, and others covered by it. If a few pigment-granules remain, they can be seen to adhere to the surface of the cell. Indeed, by care, the pigment may be left adherent to the outer ends of the rods and cones, and the cells left free from pigment. Probably the pigment-granules are cemented to the cells by a clear viscid substance.

This hypothesis that the pigment is outside the cells, gives a better explanation to some observed facts. Thus it has been noticed sometimes that a fibre, probably a radial one, has had small beads of pigment adhering to it. This has been supposed to be a process from the choroidal hexagonal cells

[1] These fibres are left after the membranous *Korb* of Max Schultze and the substance proper of the rods and cones have been removed by prolonged maceration in glycerine.

sent up between the rods and cones. It is more probably a radial fibre isolated, with some pigment adhering to it. The pigment therefore in the retina is contained between, not in, formed elements: in spaces lately described as lymph-spaces.

If we now consider the part of the retina extending from the pigment-epithelium to the intergranule-layer, it will be seen to consist of three well-marked divisions separated by layers of flat cells. In each of these divisions the arrangement of the ground-substance is based on the same plan. Thus if we look at the rods and cones we shall find, passing from without inwards, that the rods are well developed; but the cones not. The rods next diminish in calibre, while the cones increase. The same is the case in regard to the cone- and rod-pedicles. We therefore see that where there is a deficiency in the development of the one set of elements, there is a corresponding increase in the adjacent set.

Some have maintained that the rods and cones are nerve-elements. But in no instance has any direct continuity with undoubted nerve-elements, nor any quality distinctive of nerve-structure, either physical or chemical, been shown. Thus Max Schultze has described a supposed continuity which we have already shown to be merely due to branching of radial fibres. The continuity which W. Müller has lately advanced on the ground of a carmine-stained line passing from the external granule layer to the apparent surface of a cone, is not proved by the appearance even as described and figured by that observer himself. The existence of varicosity does not strengthen this view, as we are yet in ignorance of the exact conditions for that change.

Nerve-fibres from the ganglionic cells we have not been able to trace further than the molecular layer. This however is negative: and there is probably in the retina, though yet undiscovered, as abundant a nervous supply as has been shown in the cornea.

EXPLANATION OF THE PLATE.

When not otherwise mentioned, the figures are drawn from preparations of the retina of the frog, as seen by Hartnack's objective No. 7, eyepiece No. 3.

1. Radial fibre, with an elongated cell lying on it at *d*. Purpurine.

2. Another radial fibre enclosed by membrane. *b* nucleus of fibre, *c* intergranule layer, *d* external limiting membrane. Purpurine.

3. A fibre having nuclei *a* lying across inner end of "trumpet," others *b* in and around it. Several nuclei adhere to membranes in the internal granule layer. Purpurine.

4. Three fibres passing through intergranule-layer: two of them crossing and joining others to form fibres of rod-pedicles. *a* nuclei of external limiting membrane, *b* cell across the "trumpet" end. Osmic acid, macerated in glycerine, and stained with logwood.

5. *b* Fibrillary tissue lying along internal surface of retina, *c* nuclei on inner and outer surface of molecular layer, nuclei visible in molecular layer, *a* fibre with some of the membranous substance remaining. Spaces formed by fibrils from the stem radial fibre from which cells have fallen out are visible. Purpurine.

6. Flat cells lying on inner surface of internal limiting membrane. Under them blood-vessels with blood-corpuscles. Retina injected with silver solution.

7. Silver marking on membranous substance at inner end of radial fibres, from same preparation as No. 6.

8. Double layer of cell-outlines on internal surface of sheep's retina. *a* superficial, *b* deep layer. Carbolized serum.

9. Silver markings from apparent internal surface of sheep's retina. "Radial-fasern-Kegel" of German authors.

10. Internal surface of frog's retina. *a* layer of flat cells, *b* nerve-layer, *c* blood-corpuscles lying between the cells and optic nerve-layer. Gold.

11. Cells of internal surface. *a* as at *a* No. 10, *b* elongated narrow cells lying on the bundles of the optic nerve-layer.

12. Cells lying on internal surface of molecular layer *a*, ganglion-cells lying amongst them *b*. Gold and formic acid.

13. Layer of cells on external surface of molecular layer: between them radial fibres pass and give off fine processes which surround the cells. Osmic acid. Hartnack, objective 8, eyepiece 2.

14. Purpurine preparation macerated in glycerine: fine processes from radial fibres form a network for cells of internal granule-layer. *a* the outer and *f* the inner pedicle of a rod covered with their sheaths, *d* the outer with its complete sheath, *b* the outer with a nucleus on the sheath, *c* pedicle of cone, *g* nucleus on cone-pedicle, *h* external limiting membrane.

15. Hen's retina in glycerine, parallel to the surface of the retina. Molecular layer is seen to be made up of fine narrow parallel bands with nuclei amongst them.

16. Gold and formic acid preparation, showing narrow bands of molecular layer partly covered by elongated cells: parallel to the surface of the retina. Round nuclei are also seen at different parts.

17. Cells on outer surface of molecular layer with small spindle-cells lying amongst them parallel to surface of retina. Potash.

18. Layer of cells from internal granule-layer; (three such layers were seen above each other). Potash.

19. Spindle elements lying in the internal granule-layer.

20. Gold preparation, showing, *a* the external limiting membrane, and *b* intergranule-layer as homogeneous bands: effect of eight days maceration in formic acid.

21. Large nuclei of intergranule-layer and villus-like processes on surface, which belong to external granule-layer. Osmic acid.

22. Gold and formic acid preparation. *a* narrow cells, *b* nucleus on cone-pedicle, *c* nucleus on outer rod-pedicle, *d* lens-shaped body, *f* isolated cell, *e* similar cell from a potash preparation.

23. *a* Outer segment and *b* inner segment of rod, *c* "lens-shaped body," *d* cell of external limiting membrane, *e* the outer, *f* the inner rod-pedicle, *g* narrow cells on membrane connecting them, *h* nucleus of intergranule layer. Osmic acid. Hartnack, objective 8, eyepiece 2.

24. *a* Nuclei in intergranule-layer, *b* nucleus on outer rod-pedicle, *c* nucleus on cone-pedicle, *d* cellular substance between outer and inner segments of rod, *e* radial fibre bifurcating as it enters intergranule-layer, *f* external limiting membrane. Osmic acid. Hartnack, objective 8, eyepiece 2.

25. Radial fibre passing outwards through external limiting membrane. *a* nucleus, *c* external limiting membrane.

26. *e* outer pedicle of rod freed from membrane by maceration, *f* fibre passing along-side of pedicle but not in direct contact with it, *c* external limiting membrane, *d* inner segment of rod.

27. Two divisions of a radial fibre converging on the sheath of a cone. *a* fibre, *b* sheath. Cone-substance has disappeared by maceration.

28. *a* Lens-shaped body, *b* nucleus of external limiting membrane, *c* nucleus on outer rod pedicle, *d* nucleus on cone-pedicle. Osmic acid and logwood.

29. Cells on external limiting membrane of sheep's retina examined in vitreous humour sixteen hours after death.

30. *a* Granular cell-substance between the segments of the rods.

31. *a* "Lens-shaped body," *b* cell-substance between segments.

32. Cells on inner ends of outer segments of rods. Potash.

33. *a* Lens-shaped body freed from membrane, *b* external limiting membrane, *c* nucleus on outer rod-pedicle. Injected with silver solution from the heart.

34. An isolated cell from surface of rods: osmic acid and glycerine maceration.

35. Nuclei seen on the same cone in different positions, assumed by its moving under the pressure of the cover-glass. *a* narrow cell from surface of cone.

36. Cells of pigment layer. *a* cells without pigment, *b* mass of pigment between cells and ends of rods, *c* pigment between rods, *e* "lens-shaped body," *f* inner segment. Potash.

37. Internal surface from pigment-layer of ox's retina. *a* pigment still covering cell, *b* partly removed, *c* pigment completely removed.

38. Section through pigment-layer. *a* cells free from pigment, *b* pigment over and around ends of rods.

39. Radial fibre dividing into fine processes which pass upwards through external granule-layer. *a* external limiting membrane, *b* outer rod-pedicle.

40. *a* Outer rod-pedicle freed from membrane, *b* inner segment of rod, *c* external limiting membrane.

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