ON

THE DEVELOPMENT

OF

THE RETINA AND OPTIC NERVE,

AND OF THE

MEMBRANOUS LABYRINTH AND AUDITORY NERVE.

BY

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VIII. *On the Development of the Retina and Optic Nerve, and of the Membranous Labyrinth and Auditory Nerve.* *By* Henry Gray, *M.R.C.S.* *Communicated by* W. Bowman, *F.R.S., Professor of Physiology and of General and Morbid Anatomy in King's College, London.*

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THE following observations, which I have ventured to offer to the Royal Society, are intended to demonstrate the mode of evolution of the essential parts of the visual and auditory apparatus.

In the first part I have considered the mode of development of the optic nerve and retina, and also of the various layers of this membrane. In the second part, I have traced the evolution of the membranous labyrinth and auditory nerve. Many of these observations have not (as far as I am acquainted) been previously made, at the same time they will, I think, confirm in a remarkable manner the account that has already been given of the structure of these parts*.

In the minute and accurate account of the structure of the retina which Mr. Bowman has lately given in a series of lectures on the Anatomy of the Eye, he has shown that this essential part of the visual organ "is a nervous sheet containing nearly all the structural elements that are found in any part of the nervous system, consisting of an unbroken sheet of gray nervous matter, continuous by its fibrous internal surface with the axes of the tubules of the optic nerve, and having its external surface formed by a structure similar to that of the cineritious substance of the cerebral hemispheres. Its permeation by a close network of capillaries assimilates it still further to the gray nervous matter, for which reasons it may be considered as a portion of the cerebrum advanced towards the surface of the body in a suitable relation to a dioptric apparatus for the reception of rays of light from external objects."

The following observations are intended to demonstrate the evolution and mode of development of this membrane in the embryo chick, and they will, I think, confirm in a most striking manner the account that has been given of the structure of this part.

It is not until the thirty-third hour of incubation that there is any indication of the evolution of the retina or of the rudimentary eye. At the thirty-first hour (Plate VIII. fig. 1) the cephalic extremity of the embryo is indicated by its presenting a somewhat

* Some of the observations on the development of the retina may be found in my Prize Essay "On the Anatomy and Physiology of the Nerves of the Human Eye," contained in the Library of the Royal College of Surgeons, but unpublished.

dilated end, but no protrusion can be observed in the situation where the eye is to be subsequently formed. At the thirty-third hour (fig. 2) there is observed on each side of the cephalic extremity a protrusion of its walls, which at the thirty-sixth hour (fig. 3) has very much increased, having become more elongated and protruded outwards, presenting a somewhat dilated end, and being slightly constricted at its connection with the cerebral cell from which it arises; the whole embryo is enlarged, and now there is a distinct division of the brain into its several primitive cells; this protrusion, which is well represented in fig. 3, is the first distinct indication of the mode of development of this membrane.

In an embryo chick, examined at the forty-sixth hour of incubation from the cerebral aspect (figs. 4 and 5), the future brain consisted of several cells; the anterior, which was the largest, corresponded to the cerebral lobes; the middle, smaller in size, to the future optic lobes; and the posterior, the smallest, but most elongated, to the medulla oblongata. From the most anterior one there arose a protrusion on each side, having a somewhat dilated extremity: this protrusion I will call the optic vesicle. The cavity of the cerebral cell from which it arose was very distinct and its wall clear and pellucid, and appeared to communicate with the optic vesicle, which was also hollow.

As the cavity of the cerebral cell passed outwards on both sides into the optic vesicle it became less distinct, as there the wall of the vesicle, which is darkly granular, makes it in this situation less apparent, whilst the cavity in the cerebral cell itself was distinctly seen from the thinness of its wall on its ventral aspect. If the embryo is examined from its dorsal surface (its natural position in the egg), the cerebral cell presents an external convex surface, whilst projecting from each side are seen the optic vesicles. The cavity of the cell and its communication with the optic vesicle, cannot on this surface be distinctly demonstrated on account of its wall being thicker than on the ventral side. The optic vesicle is bounded externally by a well-defined line which lines the outer surface of the protrusion, and seems to be connected with the envelopes of the cerebral mass; this is again bounded by the tegumentary layer of the embryo. When examined with a high magnifying power, the vesicle presented a pale granular texture without any indication of cellular structure. This description of the origin of the retina, although confirmed by similar observations, described by BAER in the Encyclopédie Anatomique, tom. viii., is not in accordance with that of some other celebrated physiologists. According to WAGNER, the protrusion which forms the future retina arises from the middle and anterior cerebral cells, whilst HUSCHKE describes it as "a simple rudiment, consisting of a fosette; that the dorsal laminæ form in front of their anterior dilatation, the first cerebral cell ultimately dividing this into two lateral halves, from which result the two rudimentary eyes." He says also that this fosette is formed before the end of the first day. From many observations I have made I could never see what these observers have described, and, coinciding as my observations do so exactly with those of BAER, the conclusions which I have stated regarding the origin of this membrane would seem to be thereby confirmed. On examining a chick nine hours after this period, that is, at the fifty-fifth hour of incubation (fig. 6), the cavity before so distinctly seen in the anterior cerebral cell was much less apparent; the walls of the cell have also much increased in size, not only projecting upwards but laterally, so as partly to cover over the inner portion of the protruded optic vesicle, which at the second day was so distinctly seen; the head had also become more curved, which rendered a good examination of the eye somewhat difficult. On manipulating the specimen so as to obtain a view from above downwards, the embryo lying on its ventral surface, the outer portion of the protruded vesicle was distinctly seen bounded by a clear defined inner border and an outer paler one; the dark inner one was lost in the dark granular mass, which by its circular form indicated the rudimentary eye; the outer layer was the external tegumentary membrane of the embryo. At the sixty-second hour (Plate IX. fig. 8) the optic vesicle is seen to be apparently situated between the anterior and middle cerebral cells; this I believe depends on the great increase of development of these cells, and the curved form which the head now assumes, making its apparent origin to be from both, as stated by Wagner. On carefully examining it, the exterior dark line was beautifully defined all around, and presented the appearance of an outer covering to the eyeball; in this apparent cavity was seen a pyriform vesicle, the future retina, presenting a distinct outline, except at its inner side, where it became constricted and of a tubular form, and to all appearance was continuous with the cerebral mass; this constricted portion, the tubular end, I suppose to be the optic nerve, the dilated portion the retina. Internal to the retina was the circular crystalline lens, with its central but indistinct nucleus. The conclusions I have come to, from the observations made on the specimens from which the drawings 5, 6 and 8 are taken, are quite at variance with those of Huschke. He says that between the second and third days the two layers of the retina are formed in the following manner. He describes the capsule of the lens as being an inverted portion of the common integument, which pushes inwards the dilated end of the optic vesicle, and thus forms a double layer; the outer one he describes as Jacob's membrane, the inner inverted one the true retina. In order to ascertain the correctness of this statement, I examined the eye at four successive periods between the second and third days, at the forty-eighth, fifty-fifth, sixty-second and seventy-second hours. I not only examined them laterally, as they naturally presented themselves on removing them from the egg, but both on their dorsal and ventral aspect; and if the lens had been, as he described, an inversion of the integument pressing in the dilated end of the optic vesicle, both of the latter positions would have been most favourable for demonstrating it. The lens is however formed in quite a different manner; it is first seen as a rather ill-defined granular mass in the cavity of the vesicle itself, containing in its centre a nucleus: this is seen on the first half of the third day. On the third it becomes more distinct, a well-defined line now bounds its margin; between the fourth and fifth days, the granules become darker and more aggregated towards the centre, leaving a space bounded by a dark outer line; this is now the capsule of the lens, the inner one the bounding margin of the lens itself. Nor could I ever see satisfactorily any doubling-in of the retina so as to form two layers, for in no position that I put the embryo, in each of the several examinations that I made, could I ever detect but a single layer; and besides, as I shall show hereafter, JACOB's membrane is not developed until a much later period. I cannot forbear here adding the conclusions BISCHOFF has come to from his observations on this point. Although many anatomists of great reputation follow the opinion of HUSCHKE, he says, "Malgré ces autorités je dois avouer qu'il m'a été impossible même chez de très jeunes embryons de chien, de lapin, et de rat, d'aperçevoir sur la face antérieure de l'œil aucune trace d'une semblable intromission des téguments extérieurs, quoique dans certains cas, je sois resté incertain de savoir s'il existait déjà une capsule cristalline et un cristallin*."

At the seventieth hour (fig. 7) the circular outline of the eyeball has become quite distinct, not only externally, but now the line may be traced internally, where previously it was only indicated by the dark circular granular mass, the forming eyeball. The lens is also more distinctly seen bounded by its well-defined circular border, indicating its forming capsule, and the nucleus in its centre is plainly visible. When examined on its under surface, the embryo lying on its dorsal aspect, the original protrusion is seen to have become still more pyriform in shape and more constricted at its inner part, so that the more dilated portion now clearly resembles the future retina, the constricted and tubular portion the optic nerve; the more gradual contraction of this protrusion and separation of it from the cerebral mass is also now more clearly seen. The cavity, which on the second day existed in the cerebral cell and communicated with the protrusion, is now closed in, with the exception of a distinct fissure, which, commencing by curved borders at the margin of the lens, was seen to be continued inwards in the direction of the cerebral mass through the tubular portion of the protrusion, the optic nerve.

The fissure seems to be evidently connected (as BISCHOFF also supposes) with the separation which is effected between the ocular vesicle and the pedicle by which it is connected with the cerebral cell, the fissure at first being wide and extending as far as the anterior part of the eye, at its inferior and inner side; but as the tubular portion of the protrusion becomes more solidified and converted into the true optic nerve, the fissure becomes much narrowed. No doubt this is analogous to the fissure which exists permanently in the retina and optic nerve in Fishes, as is seen in the Cod. In the Turtle the fissure exists in the nerve though not in the retina, whilst in Birds it appears to be the same slit which is here described, through which the pecten gains admission into the interior of the eye.

On the first half of the fourth day (fig. 9) the whole organ seems to be increased in size: the exterior lamina was distinctly continuous all round, and was of a dark granular texture; the second layer the retina presented a different appearance to

* Anatomie Encyclopédie, tom. viii. p. 324.

what was seen on the third day; it had become more spherical in shape and increased in size; it now appeared to commence at the margin of the lens, which was situated at the more anterior part of the eye; it could not be traced around it, as in some of the preceding observations, but only overlapped it slightly by a thin beveled border, so that it appeared that the most external part of the original protruded vesicle had become absorbed to complete the formation of this rapidly developing membrane. The tubular portion of the original protrusion (the optic nerve), from the great development of the cerebral mass, was hidden from view.

On the fourth day (fig. 10) the eye had become more spherical in form, the outer envelope was distinct and darkly granular; it appeared now to terminate at the edge of the lens, whilst a paler line could be traced over this body, an evident indication of the formation of the sclerotic and cornea. The retina was now less distinctly marked on account of the dark granular tinge beneath the outer envelope; from the formation of the pigment in the epithelial cells of the choroid, it could now only be traced to the edge of the lens, not overlapping it as in the last examination: a distinct fissure was still perceptible on the under surface.

On the fifth day (fig. 11) the eye had greatly increased in size; and along its under surface the fissure was seen running, from its anterior part at the margin of the lens, to a line which bordered the back part of the sclerotic; the capsule of the lens was distinctly formed and separate from the lens itself. Both optic nerves were seen; they were tubular in form and presented a pale granular appearance; they passed inwards in the direction of the under surface of the corpora quadrigemina, but they were not united together in the chiasma until the seventh day. At this period, on making a vertical section of the organ, the retina was to the naked eye distinctly observed to arise from the margin of the lens, and could be detached from the other membranes as a perfectly distinct and separate layer.

From these observations it is seen that the retina is originally a protrusion from the anterior cerebral cell, being hollow and communicating with its cavity; that as the progressive development of the brain takes place, the optic vesicle becomes more separated from its parent cell and assumes a pyriform shape, presenting a dilated extremity, the future retina, and a tubular portion (the optic nerve). In progress of development a fissure is observed on its under surface, which is evidently connected with the separation which is effected between the ocular vesicle and the tubular pedicle (the optic nerve) which connects it with the cerebral cell. As this tubular prolongation becomes solidified so as to form the optic nerve, no communication can be traced between the optic vesicle and the cavity, from which it is an offset. By degrees the spherical end of the protrusion is absorbed, and the retina, now fully formed, becomes attached to the margin of the lens, having previously completely surrounded that body. The optic nerve can then be seen not only to be connected to the anterior cerebral cell, but uniting with its fellow at the under surface of the optic lobes, is seen partly to terminate in those bodies.

I shall proceed, in the next place, to consider the development of the various layers of the retina.

Structure of the Retina of the Chick at the Eighth Day of Incubation.

The retina may at this period be distinctly separated as a thin transparent layer from the other membranes. Its choroidal surface appears to be composed of a closely aggregated mass of globular nuclei; these bodies are about the size of the red corpuscles of the blood, and form about one-half of the entire thickness of the membrane; they apparently correspond to the "agglomerated granules" mentioned by BOWMAN as forming a considerable portion of the membrane in the normal state; they are highly refractive and of a slight yellow tinge. The deep surface of the membrane consists of some fine granular matter, and a mass of pale and exceedingly delicate nucleated cells, precisely similar to those surrounding the meshes of the fibrous lamina in the normal structure of the membrane. No trace at this period existed of either the membrana Jacobi, or the fibrous lamina of the retina.

On the Development of the Membrana Jacobi.

Between the thirteenth and fourteenth days the choroidal surface of the retina presents an exceedingly fine pale granular stratum, which covers in the "agglomerated granular mass" beneath. On the fifteenth day numerous exceedingly minute and highly refractive yellowish granules are imbedded in it; they vary in size, between the 5000th and the 8000th part of an inch in diameter, and around some of these a fine delicate cell-wall can be traced; if a good view can now be obtained of this surface, it will present the appearance of a delicate epithelial layer. This I believe to be the first stage in the development of JACOB's membrane; for on the eighteenth day the cells, which were previously of a circular form, had now become elongated, some being of an oval shape, whilst in others the almost perfect rod-like body was formed; they now lie in a slightly imbricated manner, and their nuclei, which are of a bright yellow colour, are placed at the apices of the rods; in some cases however they occupy the middle of these bodies; their deep ends are larger than their choroidal ends, and are strongly attached by this surface to the "agglomerated granular layer" beneath; so intimate is their connexion that it is difficult to get a good view of a single rod in the field whilst examining them, probably on account of their perfect separation from this layer not having yet taken place. On the twenty-first day JACOB's membrane is similar to what is seen in the full-grown bird; the rods are now closely packed together, standing perpendicularly upwards, and all of an elongated cylindrical form, their tips being occupied by the brilliant yellow bodies before noticed.

On the Development of the Fibrous Lamina.

The first trace of the fibrous lamina is seen between the fourteenth and fifteenth days: on examining the deep surface of the retina at this period, it is seen to be composed of a very fine pale granular lamina, marked by numerous faint longitudinal striæ: on the eighteenth, this lamina, when separated from the rest of the membrane, is composed of numerous fibrillated bundles, which interlacing with each other form numerous meshes, in which are deposited the gray nucleated vesicles, which are seen to be formed as early as the eighth day. On the twenty-first day this lamina presents the same structure as is found in the full-grown bird. The preceding observations can, I think, be applied in explanation of some lately disputed points in connection with the anatomy and physiology of the retina and optic nerve. And first of the retina.

This membrane has been seen to arise as a protrusion from the cells forming the future brain. Now in the microscopic anatomy of this membrane, as described by Bowman, the vesicular layer of the retina is stated to be analogous to the vesicular layer of the hemisphere of the brain, whilst Henle, and other anatomists of great note, consider the elements of this layer to be more analogous to epithelium. From the circumstance of the retina arising, as it undoubtedly does, from the cerebral cells, being in fact part of them and performing a similar function, we have, I think, a great proof of the similarity in the structure of these two parts. There is another point also, I think, of some importance in proving, as it does, that the opinion of some modern anatomists is incorrect in stating that none of the fibres of the optic nerve can be traced to the optic thalamus. I have said that the origin of the retina is from the anterior cerebral cell, and that at a future period the optic nerve could be traced uniting with its fellow of the opposite side beneath the optic lobes. It is in the anterior cerebral cell that the thalami are subsequently formed, which makes it exceedingly probable that some of its fibres are connected with it, although the greater majority may be traced to the optic lobes.

These facts I think are of some importance, and prove how deductions formed from microscopic embryology may be applied to confirm dissections or microscopic investigations made on the same parts in the mature animal.

On the Development of the Membranous Labyrinth and Auditory Nerve.

The observations I made prior to my description of the mode of evolution of the retina will almost apply here as a preface to my observations on the development of the membranous labyrinth and auditory nerve, for the essential part of this membrane consists, like the retina, of a fibrous lamina formed of the terminal axes, cylinders of the nerve tubules or of terminal loops of nerves, which are in intimate relation with a layer of dark and closely-set nucleated cells, not unlike those found lying between the meshes of the fibrous lamina of the retina; like it also, it may be regarded (as the following observations will show) as a protruded portion of the brain, modified somewhat in its texture and connected with an appropriate apparatus, which receives and transmits its peculiar impressions.

The following observations are intended to demonstrate the mode of development of this membrane, and they will, I think, confirm, not only the description given of the structure of this part, but show the striking analogy which exists between it and the retinal expansion.

At present two opinions exist regarding the evolution of the ear-bulb. It is stated by BAER that it arises soon after the appearance of the eye, in the form of a tubular prolongation of the brain, which is hollow, and communicates with the cavity of the fourth ventricle, its peripheral extremity forming a vesicular dilatation, which is gradually separated from the brain. Into this vesicle, which is the analogue of the labyrinth, there is protruded inwards a reflection of the integument, which forms all the accessory parts of the organ of hearing. HUSCHKE's account is entirely different; he says that the membranous labyrinth does not arise from the brain, but is originally a blind sac of the skin with an excretory duct, which gradually contracting, is at last separated from the common integument and exists as a separate sac beneath it. The following observations coincide partly with the description given by BAER; at the same time I shall venture to state some facts in connection with this point that have not been (as far as I am acquainted) previously noticed. In the embryo chick at the fiftieth hour, soon after the close of the second day, I observed that the medulla oblongata was not closed in above, but presented a large open shallow cavity, the analogue of the fourth ventricle. At the cephalic extremity it communicated with the optic lobes and the anterior cerebral cell by means of a small circular orifice. From the central part of the wall of this cavity, and exactly opposite to the second branchial cleft, the first rudiment of the auditory sac was visible, in the form of a small protruded vesicle of a somewhat flattened circular shape; this vesicle was hollow, clear and pellucid, and communicated with the ventricular cavity by a small circular orifice. This communication was most distinctly seen on examining the embryo from the dorsal aspect, as shown in fig. 13, where the aperture leading into the protruded sac is visible on one side, bounded by its well-defined margin. In order to satisfy myself of the correctness of this observation, and to test the accuracy of HUSCHKE's statement, I examined numerous embryos every second hour, from the thirty-sixth hour to the time when the above appearances were observed, but in none could I detect a protrusion of the tegumentary layer in that situation, and, coinciding as my observations do with those of BAER as regards the origin of this membrane, they justify, I think, the conclusions which are above stated.

At the fifty-sixth hour (fig. 14) the auditory vesicle occupies its usual position; it has become however increased in size, and has assumed a pyriform shape, so that now it presents a narrow contracted tubular portion, the rudiment of the auditory nerve, and a dilated spherical extremity, the auditory sac, or rudimentary vestibule. This latter portion projects into and becomes encased by the muscular and tegumentary layers of the embryo, forming a distinctly marked projection beneath the integument; the vesicle itself has become darkly granular and more opake, but the cavity in its interior is still distinctly seen communicating with the ventricular cavity, through the tubular prolongation of the vesicle (the auditory nerve); the aperture of communication is however much smaller, having become more contracted, and this contraction apparently increases as the separation between the auditory vesicle and its parent cell takes place. At the sixty-fifth hour (see fig. 15) the ear-bulb has increased considerably in size, and a more marked separation is now seen to exist between the auditory nerve and the expanded vestibular sac; the latter has assumed an oval shape and is now directed slightly backwards, the cavity in its interior still existing; but the auditory nerve has become now quite solidified, so that no communication exists at this period between it and the ventricular cavity. From the description which I have already given, a marked similarity may be observed between the origin of this membrane and that of the retina and optic nerve; these parts arise in both cases as a protruded portion of the cerebral mass, being hollow and communicating with the cavity of the parent cell; in process of time a gradual separation takes place between them and the parts from which they arise; they then assume a pyriform shape, but still communicate with the cerebral cavity; as however the nerve becomes solidified and more fully formed, and the separation between them is more fully effected, then no communication can be traced between the two cavities. It is in this stage of the development of the auditory apparatus in the Bird, that a remarkable similarity is to be observed between it and the normal condition of the same part in some of the lower animals. There are in fact now formed the two elementary portions of this apparatus, the auditory nerve and its vesicular bulb (the analogue of the vestibular sac). Such is the simple condition of this organ in the crustacea and in the cephalopod mollusks.

I shall, in the next place, proceed to describe the observations I have made on the development of the semicircular canals, or rather of those portions of the membranous labyrinth which line those cavities, and which are found superadded in most Birds, Fishes, and Mammalia.

At the seventy-second hour (fig. 16) the vestibular sac has become more distinctly separated from the cavity from which it originated, but is connected with it by the auditory nerve, which is fully formed and of large size; the vesicle is still quite hollow, and contains a thin limpid fluid; but its oval form is lost from a distinct contraction of its (apparent) entire circumference, which is observed about its centre; this contraction is seen to exist both on the outer and also on the inner wall, and is the first indication of the separation of the vestibule from the membranous semicircular canals, which are ultimately formed from the terminal portion of the vesicle. At the eighty-second hour (fig. 17) the contraction is observed to have become more marked, so as partially to subdivide the vestibular sac into two unequal portions; the lower one, that connected with the auditory nerve, is the future vestibule, the upper terminal one being developed into the semicircular canals; the cavity still exists in the interior of the vesicle, and the auditory nerve has increased in size. At the close of the fourth day (fig. 18) the terminal bulbous portion of the original vestibular sac has become very considerably enlarged, and of an oval elongated form; the contraction originally existing and separating it from the vestibule itself has increased very considerably, so that now a well-marked separation is seen to exist, although both cavities communicate with each other. A slight depression or shallow pit is now observed to exist at the end of the terminal vesicle, which soon becomes very distinct. This I believe indicates the first rudiment of one of the semicircular canals; no trace of the folding-in or depression of the integument in this situation could be observed.

About the sixth day this depression is more marked, and it is apparently from the amalgamation of this reflected portion and the inner wall of the vesicle with each other, that the membranous semicircular canals are formed. At first they appear to retain the same diameter throughout, but between the twelfth and thirteenth days they become somewhat contracted in parts, leaving some portions of their original diameter: it is these that apparently ultimately form the ampullæ. At about the same period a cartilaginous nidus is deposited on the outer side of the membranous labyrinth, which is soon developed into the various parts of the osseous labyrinth: at the same time also a small quantity of calcareous matter is deposited in the vestibular sac. It is interesting to observe that the membranous labyrinth between the eighth and thirteenth days has a structure almost precisely similar to that of the retinal expansion of the same period, consisting, like it, of a distinct but very delicate fibrous mesh, in the spaces between which are deposited a quantity of granular matter and numerous nucleated cells, its exterior surface being composed of a dense mass of nuclei, almost precisely analogous to the "agglomerated granules" which form so large a portion of the entire substance of the retina. From the preceding observations the following conclusions may be drawn.

That the membranous labyrinth, like the retina, is a protruded portion of the brain, being hollow and communicating with the ventricular cavity from which it arises. As the progressive development of the brain proceeds, the auditory sac becomes more elongated and of a pyriform shape, the dilated portion being analogous to the vestibule, the contracted tubular portion to the auditory nerve; this subsequently becomes solid, and the cavity in the vestibule does not then communicate with the ventricle, from the wall of which it is an offset. This representative of the normal condition of the organ in some of the lower animals now takes on a higher form of development, for the membranous semicircular canals are now added to the vestibule, being formed by a contraction, and subsequently, a folding inwards and union of a portion of the walls of the vesicle itself; lastly, the walls of these canals becoming in parts contracted, the dilated ampullæ are formed.

Explanation of the Plates.

PLATE VIII.

Fig. 1. An embryo chick at the thirty-first hour of incubation.

Fig. 2. An embryo chick at the thirty-third hour.

Fig. 3. An embryo chick at the thirty-sixth hour. The first rudiment of the eye is here seen to be visible in the form of a protrusion from the anterior cerebral cell.

Fig. 4. An embryo chick at the forty-sixth hour. The optic vesicle is seen now very distinct, presenting a slight contraction at its connection with the cerebral cell from which it arises.

Fig. 5. The cephalic extremity of a chick at the same period more highly magnified. This Plate is intended to represent the cavity which exists both in the cerebral cell and optic vesicle, and the communication between them.

Fig. 6. The cephalic extremity of an embryo at the fifty-fifth hour viewed from the dorsal aspect, principally intended to represent the mode of formation of the crystalline lens.

Fig. 7. The under surface of the eye of a chick at the seventieth hour. This figure shows the spherical form of the eyeball, its contracted tubular end, the optic nerve, the mode of formation of the lens, and the fissure which exists on the under surface of the eye.

PLATE IX.

Fig. 8. The cephalic extremity of an embryo chick at the sixty-second hour (lateral view).

Fig. 9. In this Plate the retina is seen overlapping the margin of the lens at the latter half of the third day.

Figs. 10 and 11. The eye of an embryo chick on the fourth day.

Fig. 12. The eye of an embryo chick on the fifth day.

Fig. 13. In this Plate the first rudiment of the ear is visible in the form of a small vesicular protrusion from the central part of the medulla oblongata (from an embryo chick at the fiftieth hour of incubation).

Fig. 14. An embryo chick at the fifty-sixth hour. The ear-bulb is now seen to be of a pyriform shape, and communicating with the cavity from which it arises.

Fig. 15. The cephalic extremity of an embryo chick at the sixty-fifth hour of incubation. The rudimentary vestibule and auditory nerve are now seen fully formed.

Fig. 16. The ear of an embryo chick at the seventy-second hour of incubation. The

auditory nerve is now seen quite solid, and the vestibule presents a slight contraction near its centre.

Fig. 17. An embryo chick at the eighty-second hour, viewed from the dorsal aspect. The cavity of the fourth ventricle is distinctly seen, and on either side the rudimentary ear is shown *in situ*; the contraction of the wall of the vestibule is more marked.

Fig. 18. The ear of an embryo chick at the ninety-sixth hour. The vestibular contraction is more marked, and a depression is observed at the extremity of the terminal vesicle, which subsequently forms one of the semicircular canals.

8 *Wilton Street*,
October 14*th*, 1849.

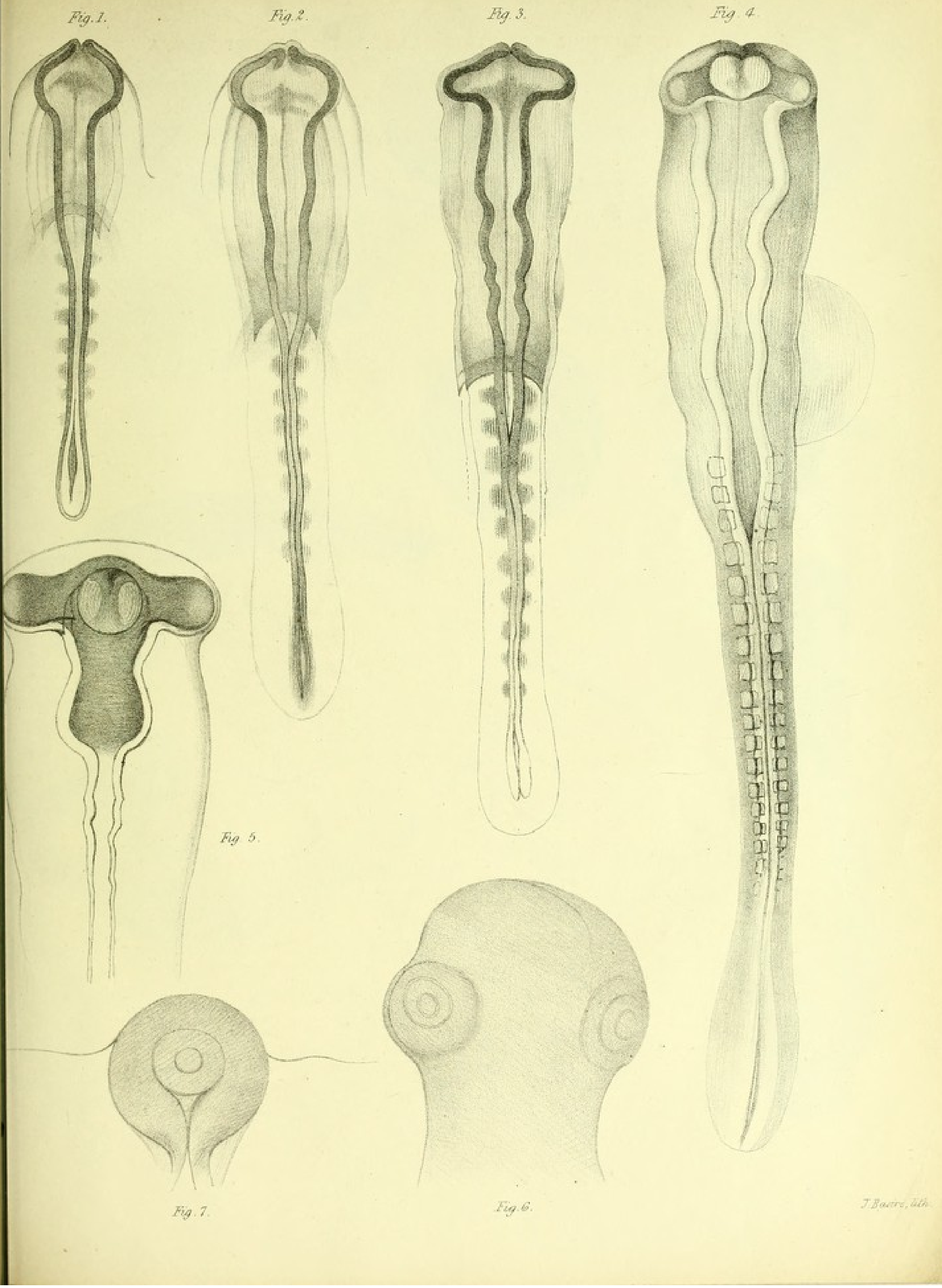
Fig. 1.
Fig. 2.
Fig. 3.
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Fig. 6.
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Fig. 9.

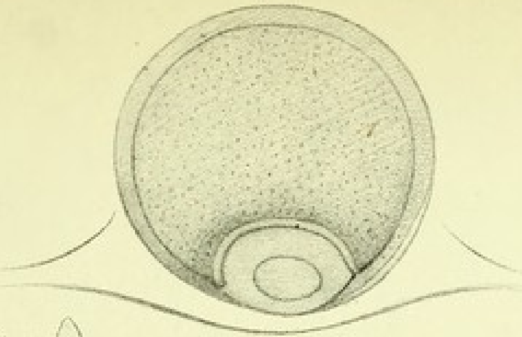


Fig. 10.

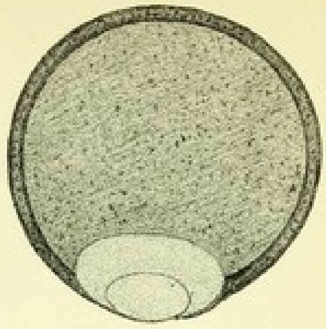


Fig. 8.

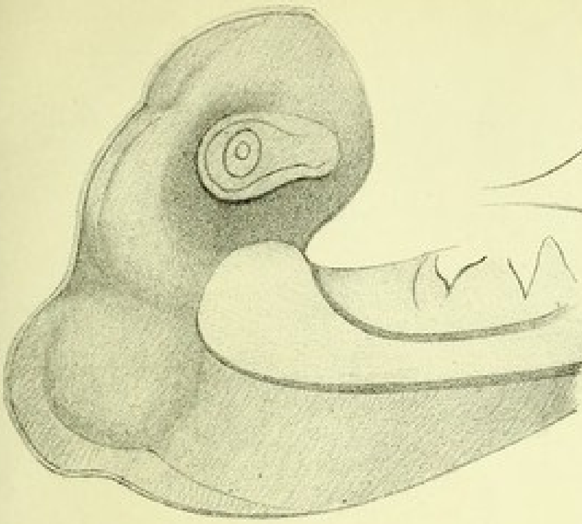


Fig. 12.

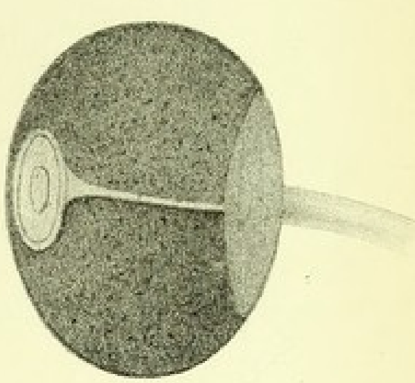


Fig. 11.

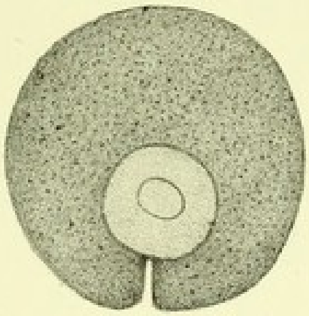


Fig. 13.

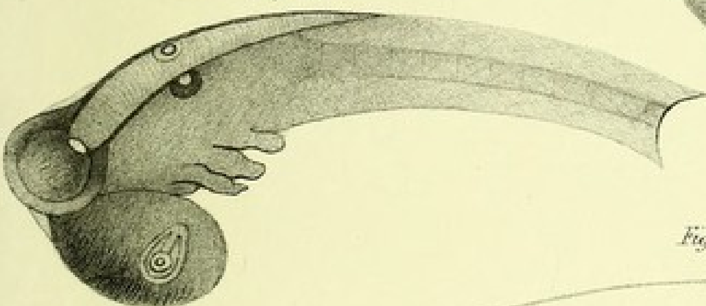


Fig. 17.

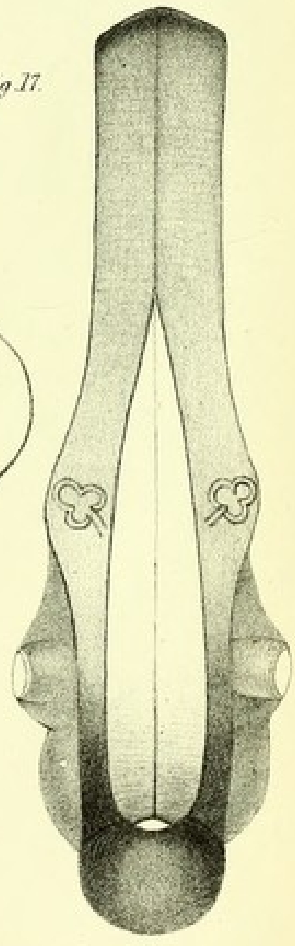


Fig. 15.

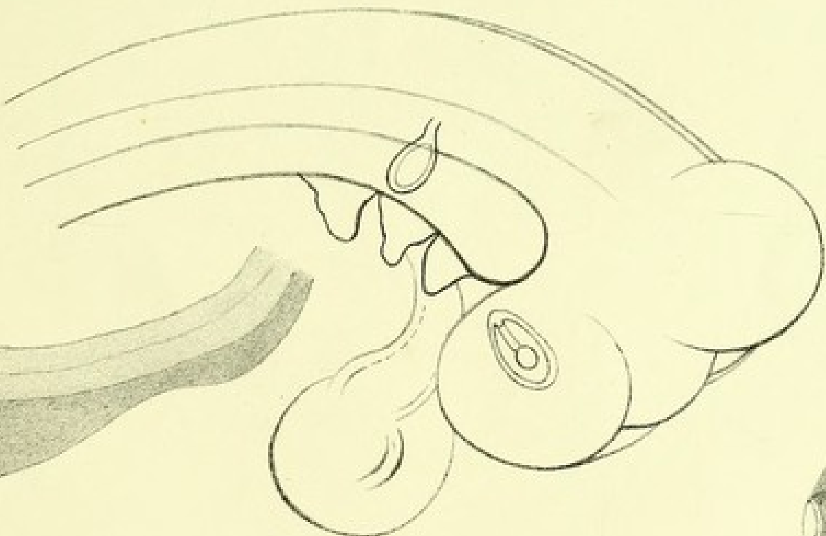
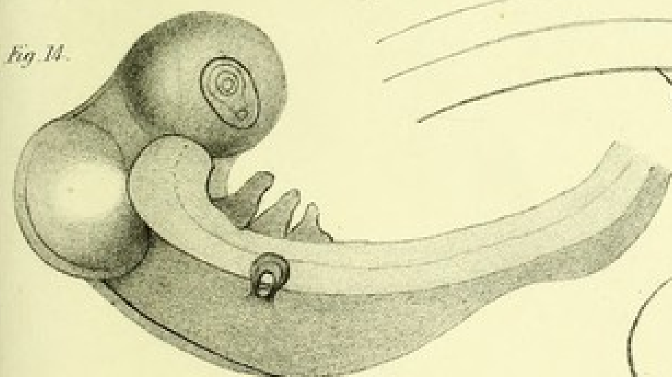


Fig. 14.



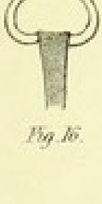


Fig. 16.

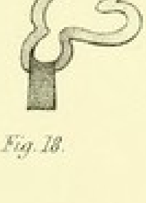


Fig. 18.

J. Basire, lith.