A COMPARATIVE SKETCH

OF THE

EARLY DEVELOPMENT OF THE EAR AND EYE IN THE PIG,

TOGETHER WITH

A NEW ACCOUNT OF THE DEVELOPMENT OF THE MEATUS EXTERNUS, DRUM, AND EUSTACHIAN TUBE.

BY

DAVID HUNT, M. D.,

BOSTON.

[*REPRINT FROM THE TRANSACTIONS OF THE INTERNATIONAL OTOLOGICAL CONGRESS*, 1876.]

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A COMPARATIVE SKETCH OF THE EARLY DEVELOPMENT OF THE EAR AND EYE IN THE PIG, TOGETHER WITH A NEW ACCOUNT OF THE DEVELOPMENT OF THE MEATUS EXTERNUS, DRUM, AND EUSTACHIAN TUBE.

By DAVID HUNT, M. D., Boston.

Until 1831, when Huschke gave the true account of the development of the inner ear, the ideas of Von Baer misled most of those who investigated the subject. Huschke's account was not generally received, until Reissner, Remak, and Bischoff confirmed it; since then most of the details have been worked up by Böttcher, Middendorp, Hensen, and others, and an excellent *résumé* was given by Kölliker in his "Entwickelungsgeschichte" in 1861. In France and England little of value has been done in this department, and in our own country our best text-books on physiology repeat the errors of fifty years ago.

As to the development of the inner ear, it is now known that an involution of the integument of the embryo forms a sac; by processes to be described this sac forms the cochlea, semicircular canals, vestibule, and accessory parts.

The meatus auditorius externus, drum-head, middle ear, and Eustachian tube, are described as originating from the first branchial cleft which, growing together in its middle portion, forms the drum; the sections of the fissure outside and inside of this point form respectively the meatus externus and the Eustachian tube. I believe that this view of the development of these parts is incorrect, and shall in this paper state what I believe to be the fact on this point.

Von Baer gave an account of the development of the primary optic vesicle that has held its own against the view of Huschke; in regard to what we now call the secondary vesicle, Von Baer made a mistake that misled many after him; he located the vitreous between the two layers of the retina formed by the folding in of the primary vesicle, or, what amounts to the same thing, in the primary optic vesicle.

In 1830 Huschke described the involution of the lens Remak confirmed his observations, and soon after Vogt and Remak described the manner of growth of the lens fibres from the epithelium of the lens vesicle. Schultze, Müller, Babuchin, Iwanoff, Zernoff, Kessler, Lieberkuhn, and others, have done much in clearing up special points. Prof. Arnold's last contribution, "Beiträge zur Entwickelungsgeschichte des Auges," contains one of the most correct and practical accounts that we possess; he follows the process in one species and in an almost complete series of embryos of different ages.

The eye is first formed by a protuberance from the brain, which consists of a hollow stem—the optic nerve—the expanded extremity of which forms a globe, the primary eye vesicle; soon the lens is formed by a thickening and involution of the integument over the vesicle; this process—the involution of the lens—turns the anterior half of the primary vesicle inward; the cavity thus formed is the secondary optic vesicle. The succeeding stages will be described in detail, and a comparison made with the corresponding stage of development of the labyrinth.

Embryo Pig, ⅜ of an Inch long: Ear.—The otic vesicle is ovoid, the recessus labyrinthi forms a wide-mouthed diverticulum from its upper extremity, the apex of the recessus is surrounded by a thick network of blood-vessels, the commencement of the choroid plexus; at this time the blood-corpuscles vary much in size, and many have a large, round, granular nucleus; sections of the blood-vessels show the nuclei of the cells which formed their walls.

Eye.—The eye at this time is a much more complicated structure: the primary optic vesicle has been doubled in by the inversion of the lens, which at this time is a mere depression of the integument; the cylinder cells in the bottom of this depression are longer than those on its side and on the neighboring surface; the depression itself is filled by a collection of delicate, round, slightly granular cells, which in all probability hold the same relation to the cylindrical cells that the epithelial scales hold to the rete malpighii. I have not been able to find the longitudinally striated layers described by Arnold as covering these round cells; accordingly my sections agree exactly in appearance with Fig. 2, plate xxi., in the 11th vol., 3d part, of the *Archiv für Mikroskopische Anatomie*, where Mihalkovics states that he also is unable to find the layer in question. When the epithelium folds in to form the lens, it carries with it a layer of the connective tissue upon which it rests; this now appears as a hyaline substance in which blood-vessels are rapidly developing; blood-corpuscles are also formed in the layer of tissue bounding the vesicle on the outside. It is interesting to know that blood-corpuscles are seen in this location before a trace of pigment is seen in the retina.

15 *Embryo Pig, [illegible]/32 of an Inch long: Ear.*—The otic vesicle is considerably changed in appearance; it looks now as if compressed from without inward and then flexed, so that it forms a curve with the convexity outward; the apex of this curve is the point at which the horizontal semicircular canal buds out; from the superior extremity there are now two diverticula, one the recessus, and one for the vertical semicircular canals; a slight depression on the inner wall marks the position of the future sacculus rotundus; the epithelium is much thicker at the inferior portion of the sac where the cochlea is budding out and thinnest over the vertical semicircular canal. This form of the labyrinth is evidently intermediate to those illustrated in Figs. 8 and 9, plate 1, by Böttcher, in his "Entwickelung und Bau der Gehörlabyrinth," yet the embryo whose labyrinth I have described was shorter than that from which Fig. 8 was drawn. Although Böttcher used fœtal sheep, I think that the difference results from the difficulty, referred

to by Bischoff, of exact measurement of fœtal development by means of noting the length.

Eye.—The lens is now almost separated from the epidermis; the mouth of the previous depression closes like a purse when the string is drawn; the lens is round; the epithelial wall in its whole circumference consists of cells of like shape, accordingly the cavity in the lens is round; it is filled with cells of the same character as those described as filling the previous depression of the integument which then formed the lens; the inner layer of the retina is four or five times thicker than the outer; the retinal pigment is seen in the anterior portion of the outer layer; it occupies the inner end of the cells constituting this layer of the retina, and not the outer part, as Manz expressly states in the Graefe-Saemisch "Handbuch." Between the lens and the inner retinal layer the hyaline tissue contains a greater number of blood-vessels; some were carried in with the connective tissue that was pushed in by the lens, some pass through the so-called choroideal fissure. It seems to me that the lens turns in from a position downward and forward.

Pig Embryo, $\frac{9}{16}$ of an Inch long: Ear.—In the embryo $\frac{3}{8}$ of an inch, we described the recessus labyrinthi as a process leading from the upper part of the sac; in the embryo $\frac{11}{32}$ of an inch long, the vertical semicircular canals formed another; in the embryo $\frac{9}{16}$ of an inch long, we can no longer speak of processes, as the whole upper part of the sac is composed of the narrow recessus and the wide cavity of the vertical semicircular canals. Just at the mouth of these canals is a sharp projection outward of the wall of the vesicle; this is the commencement of the horizontal canal. Just below the opening of the recessus on the inner wall is an indentation, the site of the formation of the sacculus rotundus; the lower portion of the vesicle hooks inward under the brain; this hook is the beginning of the spiral of the cochlea; the ganglion of the cochlear nerve is plainly seen; delicate fibres connect it with the epithelium in the cochlear canal.

Eye.—The lens has undergone a most interesting metamorphosis; the cells on the posterior wall have now become lens-fibres, which reach forward about two-thirds of the distance to the anterior wall; naturally the central fibres are the longest; the fibres on the surface are slightly curved, concavity outward; the central fibres are straight; the fibres increase in size from their centre to their anterior extremity, where they present on cross-sections a perfectly amorphous interior and a sharply defined contour; between the termination of the fibres and the anterior surface of the lens is a space filled with protoplasm; it is natural to associate this appearance with the disappearance of the delicate cells that formed the contents of the lens before the fibres commenced their growth, but I know of no direct proof that there is any connection of the two processes. In the vitreous a large number of blood-vessels are seen which ramify upon the surface of the lens; they enter with the optic nerve and through the embryonic fissure; just anterior to the fissure is a cluster of blood-vessels.

Pig Embryo, $\frac{11}{16}$ of an Inch long: Ear.—The semicircular canals and cochlea have progressed considerably in their development; the indentation for the sacculus is deeper, but the general appearance of these parts is not strikingly different from that in the embryo $\frac{9}{16}$ of an inch long; the connective tissue surrounding the labyrinth has been transformed into cartilage. In sections of the head at this age, I have seen appearances that would indicate that the cochlear and vestibular branches of the auditory nerve arise from separate roots.

Eye.—The] lens-fibres have nearly reached the anterior surface; the epithelium of the lens is thinner in front, but increases gradually in thickness to a point about half-way between the equator and posterior pole, where the epithelial cells pass over into lens-fibres; a small triangular cavity exists at the posterior pole; this space is filled with large, round globules that have no structural characteristics; the layer of nerve-cells has commenced forming in the retina; anteriorly, where the posterior layer of the retina passes over into the anterior layer, the character of the cells composing the retina is changed; the body of the cell is here long and narrow; in the other parts of the retina the cells consist of oval nuclei and delicate processes; the pigment is very abundant; the layer of connective tissue at the site of the cornea has increased in thickness, and the membrana capsulo pupillaris is in the position occupied later by Descemet's membrane; the lids have commenced forming.

Pig Embryo, ⅞ of an Inch long: Ear.—The cartilaginous labyrinth is clearly defined; the recessus labyrinthi now lies in the connective tissue forming the dura mater, excepting its vestibular end, which lies in cartilage; the dura mater fills out the angle formed by the junction of the temporal and petrous cartilages; in the apex of this angle a sinus has formed; not far from it is seen the extremity of the recessus; the semicircular canals have a hardly perceptible lumen; the cochlea has one and one-half turns; its epithelium is thick and is easily detached from the surface beneath; the greater epithelial protuberance has commenced forming.

Eye.—Here a marked change is seen; the sclerotic and cornea can be easily distinguished; the cornea is considerably thicker than the sclerotic, and the corneal corpuscles are seen; they appear to be the developed nuclei of connective-tissue cells, some of which are seen among the corpuscles unchanged; the membrana capsulo pupillaris adheres to the posterior surface of the cornea; the formation of the ciliary body has begun; it is composed of connective tissue from the neighborhood of the corneo-scleral junction, of transformed cells of the retina, and of tissue from the vitreous; its apex is drawn out into a thin hyaline structure that covers the surface of the lens; the lens is solid; in the retina there is an evident stratification; when the two layers of the retina are separated, the limitans goes with the internal layer, and a hyaline substance is discovered that adheres partly to the limitans and partly to the outer layer.

Meatus Externus, Drum, and Eustachian Tube.—The idea that the Eustachian tube, tympanum, and external meatus are formed from the first branchial cleft, was first published in the *Isis* by Huschke in 1827. Von Baer did not coincide with this view. In 1828 he described the development of these parts more in accordance with what seems to me to be the truth. Huschke's view as to the development of the otic vesicle was soon proven to be correct, and Von Baer's error on this point no doubt weakened his authority on the one in question. Von Baer did not follow the development of the ear very closely, as he himself states on page 146, vol. i., of his "Entwickelungsgeschichte der Thiere," so that his descriptions lacked the necessary accuracy. Huschke's statements have been accepted by every writer on development with whom I am acquainted. Kölliker, in his deservedly popular "Entwickelungsgeschichte," gives the history as follows: "The first branchial cleft, which is fully open in the human embryo at the fourth week, closes in the fifth week, not, however, in its whole length, as do the other clefts, but so that at both sides of the place of closure, which lies near the outer opening, the beginning and the inner end of the canal remain open; these parts are nothing other than the sites of the meatus auditorius on the one side and the Eustachian tube and the tympanum on the other."

The history of the development of these parts, as I have found it, is as follows: The Eustachian tube is an involution of the mucous membrane of the pharynx; it is not in any way the remains of a branchial fissure, but lies in the tissue in which the base of the skull is forming; it grows in length as the branchial fissures close. When the cartilaginous cochlea is first formed, the Eustachian tube lies under it, and follows its outline to the site of the middle ear, which at an earlier date is principally indicated by the ganglion of the facial nerve.

The meatus externus is formed as follows: The first branchial cleft in an embryo $\frac{3}{8}$ of an inch long is very narrow; in its middle portion there is a slight protuberance of the second branchial arch that breaks the otherwise straight course of the fissure. In an embryo $\frac{5}{8}$ of an inch long, the cleft is closed, excepting that, at the point at which the projection of the second arch was situated, there is a shallow depression remaining; this point corresponds nearly to the middle section of the cleft. The process of closure is interesting: the ends of the inferior maxillary process of the first branchial arch grow together very early—they are joined in an embryo $\frac{3}{8}$ of an inch long—soon after, the second arch closes in front, and at the same time fuses with the first arch in its ventral portion, so that the first branchial cleft is obliterated as far as the inner end is concerned; as a result of this process the buccal cavity is closed in. The outer end of the first fissure, seen in profile views of the embryo, has also closed down to the furrow mentioned above, which is situated on the side of the embryo just above the blunt angle formed by the junction of its lateral and ventral surfaces; this depression is a shallow one, and does not represent the whole depth of the fissure; the first and second arches are united beneath it; bisect an embryo $\frac{5}{8}$ of an inch long in the antero-posterior median plane, separate the walls of the buccal cavity, and the site of the depression is seen to be occluded by a thin, translucent layer of tissue. Now, the projection of the second branchial arch increases in bulk and becomes more pointed, but the thickness of the fold makes the point appear rather blunt at first; the tissue of the first arch on the opposite side of the depression forms a slight ridge. When this point is reached (in an embryo $\frac{3}{4}$ of an inch long, or little less), the meatus externus commences as a burrow into the tissue of the first branchial arch—or rather into tissue that did compose the arch, for the arch has now disappeared. In an embryo $\frac{7}{8}$ of an inch long, the meatus is very apparent, the pointed protuberance above spoken of is much thinner, and is now easily recognizable as the auricle; it points forward; the meatus is not only deeper, but, as a proof that the process of its formation is an active process, its termination is much nearer the Eustachian tube. A section of the embryo at this stage shows that the meatus has extended so deeply that its inner extremity lies under the outer portion of the Eustachian tube—in fact, is almost in contact with the tube; the portion of connective tissue lying between meatus and Eustachian tube is the membrana propria of the drum, the meatus forming its dermoid or inferior surface, the Eustachian tube its superior or mucous surface. In the connective tissue above, and posterior to the location of the drum, the ossicles have commenced forming; the stapes does not, as most authors state, form later than the other ossicles, but, no doubt, it appears later in the tympanum. Its first appearance seems to be rather in the vestibule than in the tympanum, not free in its cavity, for it is connected with its cartilaginous walls.

This position of the stapes is caused by a gradual absorption of the cartilaginous wall of the vestibule at this place, caused apparently by the growth of the stapes. I am not aware that this explanation of the formation of the oval window has ever been given; it is, at least, as satisfactory as the ordinary statement, that the "oval window is a portion of the vestibular wall in which ossification did not take place."

According to this view of the development of the parts in question, the concha is the only opening left in the closure of the first branchial fissure, and the furrow bounding the lower border of the under jaw indicates the course and line of closure of the cleft.

I have found it utterly impossible to obtain a satisfactory idea of this part of the history of development, as it has been heretofore presented. In what manner were the dermoid and mucous surface of the drum formed? How did the drum obtain the horizontal position which characterizes it in the embryo? How did the Eustachian tube reach its position at the base of the skull in parts not at all concerned with the branchial fissures? These and many other questions it left unanswered.

The congenital malformations of this part are also but so many puzzles, considered in the light of the ideas that have hitherto prevailed as to its development; for, if those ideas were true (since the most common cause of such malformations is arrest of development), we should expect to find absence of the drum, a meatus or Eustachian tube with fissures in their walls, as the most common congenital defects. Instead of this, occlusion of the meatus is the most common malformation; this, according to the views which we present, is due, as it should be, to the most common cause, viz., arrest of development.

It would be out of place to speak of the phylogenetic relations of the facts here presented, although they are interesting.

To recapitulate: The Eustachian tube is an involution of the pharyngeal mucous membrane; the meatus is an involution of the integument; the drum is formed by the Eustachian tube overlapping the extremity of the meatus.