An Outline Of The Embryology Of The Eye (1893)

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AN OUTLINE

OF THE

EMBRYOLOGY OF THE EYE

WITH ILLUSTRATIONS FROM ORIGINAL
PEN-DRAWINGS BY THE AUTHOR

BY

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PREFACE.

THE following study, carried out in the New York Ophthalmic and Aural Institute at Prof. Knapp's suggestion, is based upon the examination of a great number of specimens. The chick-embryos were obtained by incubation, and were hardened in Kleinenberg's or Müller's fluid, and stained with carmine and hematoxylin-eosin. The pig-embryos were obtained fresh and hardened in Müller's fluid, after decalcifying, when necessary, with phloroglucin or hydrochloric acid mixtures, and the sections were stained mostly with hematoxylin-eosin. Some of the breaks in my series were supplied by Dr. B. Alex. Randall of Philadelphia who kindly lent me a number of his specimens, prepared by Dr. Piersol.

W. A. H.

37 WEST 39TH STREET, NEW YORK,
August 15, 1893.

AN OUTLINE OF THE EMBRYOLOGY OF THE EYE.

[The drawings referred to by numbers will be found on the plates at the back of the volume.]

In endeavoring to present a clear and comprehensive description of the development of the eye, it has seemed to me best to give first a brief and purely schematic sketch of the processes which take place, explaining them with diagrams, and next to give an accurate histological description of the various parts of the eye in their successive phases of development, illustrating these descriptions with careful drawings from actual preparations. It will be noticed that the text is not burdened with frequent references to the voluminous literature of the subject. The microscopic descriptions are the unprejudiced interpreta-

tion of what I have myself seen. When some essential point has not been shown in my specimens, an authority that has described it is quoted. In regard to some disputed points the views held by different authorities are given.

The earliest periods up to the formation of the lens-sac have been studied in the embryo-chick, and the later periods, on account of the difficulty in obtaining a complete series of human embryos, have been studied in the fœtal rabbit and pig, the eye of the latter closely resembling that of man.

I.—A Sketch of the Processes Occurring.

At an early stage the ovum consists externally of a layer of closely packed cells having a definite form and arrangement (the epiblast), and beneath or internal to the epiblast of a layer of loosely connected branched cells of irregular form (the mesoblast). As the hypoblast does not take part in the development of the eye, it need not be spoken of here.

Very early in the development of the epi-

blast a linear furrow forms upon its inner surface, and the portion of epiblast surrounding this furrow becomes thickened so as to dip down into the mesoblast and push the furrow before it. At length this furrow closes and, becoming separated from the external epiblastic layer, forms a long narrow tube, the neural canal, which is the beginning of the cerebro-spinal axis (Fig. A).

FIG. A.

This tube becomes dilated at the extremity where the brain is to be formed, and constrictions divide the dilated portion into three parts, called the anterior, middle, and posterior *primary* cerebral vesicles. Later the anterior and the posterior primary vesicles each divide again, forming thus five *secondary* cerebral vesicles.

The first important step to occur in the development of the cerebral system is the bulging out of a small portion of the lateral wall of the anterior primary cerebral vesicle on either side, forming a cavity called the primary optic vesicle (Fig. B). This primary

FIG. B.

optic vesicle, which is thus formed from the involuted or neural epiblast, pushes out until it reaches the external epiblast. At the spot where the vesicle is in contact with the external epiblast, the latter becomes thickened and cupped (Fig. C). This cup closes, forming a

FIG. C.

sac—the lens-sac,—which becomes detached from the external epiblast (Fig. D). The

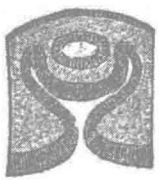

FIG. D.

anterior cells of this sac form the anterior layer of epithelium of the lens, while the cells of the posterior layer of the sac develop into the nucleated fibres which extend forward and make up the substance of the lens.

As the external epiblastic layer becomes cupped to form the lens, the distal wall of the primary vesicle is first depressed, and then, inasmuch as the vesicle continues to grow, it is gradually involuted until it comes to lie in contact with the proximal (posterior) wall. The double-walled cup thus formed is called the secondary optic vesicle (Fig. E).

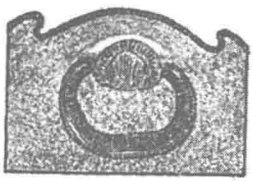

FIG. E.

The cupping of the primary optic vesicle, however, is not confined to its distal wall, but also takes place in its inferior (ventral) wall, so that the secondary optic vesicle has a circular opening distally, occupied by the lens, and a cleft inferiorly, which extends back into the pedicle connecting the optic with the cerebral vesicle. This pedicle, or optic stalk, is the rudiment of the optic nerve (Fig. F).

FIG. F.

Later the margins of this cleft unite, and the latter is obliterated. In the mammalia, however, before the cleft closes, mesoblastic

tissue passes through it into the cavity of the secondary vesicle. Previously a small quantity of mesoblastic tissue has been carried in with the lens and takes part in the formation of its vascular sheath, but a greater quantity of mesoblastic tissue passes through the inferior cleft and forms the vitreous, which is an almost structureless substance containing blood-vessels. The vessels entering first at the posterior extremity of the cleft divide into two systems of branches, one of which runs forward in the vitreous near the wall of the cavity, and another runs to the posterior pole of the lens where it breaks up into innumerable twigs which lie in the vascular sheath of the lens.

The cleft in the optic stalk closes about these mesoblastic vessels and they come to lie in the centre of the optic papilla, the branches which run in the vitreous being obliterated before birth.

As soon as the secondary optic vesicle is formed, its two layers begin to differentiate,

the internal or distal layer becoming thicker to form the retina, and the external or proximal layer diminishing to a single stratum of cells, which become pigmented and form the pigment-epithelium.

While this differentiation is taking place, the mesoblastic tissue just about the vesicle becomes denser and many blood-vessels appear in it, forming the rudiment of the choroid.

Mesoblastic tissue also pushes out just behind the external epiblastic layer and forms the rudimentary cornea, the external epiblastic layer forming the epithelium. A single layer of unbranched mesoblastic cells covering the primitive cornea posteriorly becomes the corneal endothelium, and this secretes Descemet's membrane.

In the meantime the secondary vesicle grows much faster than the lens, and the folded margins of the vesicle-wall which remain in contact with the lens are drawn inward, thus beginning the formation of the iris. A sheet from the surrounding mesoblast passes out

over the margin of the vesicle-wall and becomes continuous with the anterior portion of the vascular sheath of the lens, forming the pupillary membrane. The epiblastic vesicle-wall and mesoblastic sheet develop simultaneously to form the iris. The pupillary membrane together with the remainder of the vascular sheath of the lens is absorbed before birth.

As the vesicle-wall grows, it is thrown into a fold near the equator of the lens, and this fold becoming filled with mesoblastic tissue forms the ciliary body. Further growth of the vesicle in an equatorial direction produces a number of meridional folds, which form the ciliary processes.

At this time the distal wall of the vesicle, which in its posterior portion thickens to form the retina, thins down in its anterior portion to a single layer of cells. This layer is called the pars ciliaris retinæ in that portion which covers the ciliary body, and becomes pigmented and forms a portion of the uveal layer where it covers the posterior surface of the iris.

The lids are formed by folds of epiblast thrown out above and below, into which mesoblastic tissue pushes. These folds as they develop cover the cornea and finally meet. The epithelium of either lid margin proliferates and joins with that of its fellow, thus connecting the lids securely together and forming a closed sac, the conjunctival sac. This sac is lined by the epiblastic layer, which remains as the epithelium of the conjunctiva. The connective-tissue portions of the lid are derived from the mesoblast.

The lachrymal duct is formed from the lachrymal furrow (Fig. 19, A and B), a groove lined with epiblast, extending from the eye to the olfactory opening. This groove forms a canal and becomes separated from the external epiblast.

To return and trace the development of the cerebral vesicles. Their walls, as we have seen, consist of a layer of involuted epiblast or neural epiblast. The first marked change to occur is that the posterior portion of the wall

of the anterior primary vesicle—which subsequently becomes the second secondary cerebral vesicle—bulges out to form the primary optic vesicle. From the primary optic vesicle develop the pigment-epithelium and the retina proper, which latter may be divided into, 1st, the cerebral layer (nerve-fibres, ganglion-cells, etc.), conducting elements, and, 2d, the layer of modified neural or sensory epithelium (outer nuclear layer, rods and cones), which makes up the percipient elements of the organ of vision. The lens and conjunctiva originate in the external epiblast, and the remaining structures of the eye arise from the mesoblast.

Soon after the formation of the optic vesicle, the auditory vesicle appears near the fifth secondary cerebral vesicle. The auditory vesicle, however, is not formed by a bulging of the neural epiblast composing the cerebral vesicle wall, but by an indipping of the external epiblast, forming a closed sac and afterwards becoming separated from the external epiblast. This sac becomes the epithelial

lining of the labyrinth—the modified sensory epithelium forming the percipient elements of the organ of hearing. The auditory nerve pushes out to it from the brain at a later period.

The neural epiblast undergoes a thickening in its entire extent and forms the brain and cord, the cavity remaining as the cerebral ventricles and the spinal canal. The first vesicle forms the cerebral hemispheres, the corpus callosum, lateral ventricles, etc.; the second (thalamencephalon) gives rise to the retina and optic nerves by means of its prolongation, the optic vesicle, while its lateral walls thicken to form the optic thalami, its roof to form the pineal gland, its floor to form the pituitary body, and the cavity remains as the third ventricle. The early embryonic relations undergo a considerable change, however, and the optic tracts later connect the eye with the third cerebral vesicle (mesencephalon), from which arise the corpora quadrigemina. The fourth vesicle gives rise to the cerebellum and pons, and the fifth to the medulla oblongata.

II.—Histological.

1. *Primary optic vesicle.*—The wall of the primary optic vesicle is the direct continuation of the neural epiblastic layer forming the wall of the cerebral vesicles (Fig. 1, A). For a considerable time its histological structure does not change. It consists of cells, somewhat similar to ordinary epithelial cells, in a layer from three to five cells deep, more or less regularly superimposed in a radial direction, the limits of the cell-bodies being mostly indistinct. The external and the internal margins of the layer are sharp and regular.

Outside the cerebral vesicles lies the mesoblast composed of branched cells not closely packed, and containing many thin-walled blood-vessels, which lie for the most part near the wall of the vesicles. Covering the whole is the external epiblast, a homogeneous layer of protoplasm with a single row of granular nuclei.

In birds the primary optic vesicle reaches the external epiblast, there being no mesoblastic cells between the two. In mammals,