

ment only to increase the number of the epithelial components or their products of metamorphosis, the ependymal cells. By the continuous proliferating activity of the '*Keimzellen*' a considerable number of ependymal cells (at least in the case of higher Vertebrates) are gradually created. Thus a definite framework is brought into existence, in the meshes of which further processes of cellular development take place on prescribed lines. About this time the most important differentiations in the neural tube begin. The descendants of the '*Keimzellen*' ceasing gradually to turn into ependymal cells are transformed into the mother cells of future nerve cells which, provided with certain histological characteristics, are expressively named '*neuroblasts*.' In the highest Vertebrates, moreover, the offspring of the '*Keimzellen*' appear, provided with still *higher capacity of differentiation*, in so far as they produce a generation of '*indifferent cells*,' which later on differentiate into either *nerve* or *neuroglia cells*.

2. The *ependymal cells*, as a whole, are to be considered as a *phylogenetically older* or an *embryonic stage* of supporting tissue which, in the ascending series of the Vertebrates or in the progress of ontogenetical development, loses gradually its morphological and physiological importance, and is at last replaced by a *cænogenetic* form of supporting tissue, the *neuroglia* proper, the elements of which originate, like the nerve cells, from '*indifferent cells*.'

3. The '*indifferent cells*' have the property of *locomotion* (especially developed in those of the cerebellum, where they give rise to the formation of the superficial granular layer of *Obersteiner*), a characteristic of the formative elements of the nervous system which is of great importance for a higher structural complication of the latter.

4. The so-called '*Mantelschicht*' of *His* is in the higher Vertebrates composed of '*indifferent cells*' (not only of neuroblasts as

*His* supposes), which later on differentiate into either *neuroblasts* or *spongioblasts* (the latter being the mother cells of neuroglia cells).

5. Not all *indifferent cells* undergo simultaneously such an early process of differentiation. A certain number remain for a longer or shorter time in an indifferent condition possessing moreover the property of *further propagation*, which activity is clearly shown by the appearance of karyokinetic figures within the '*Mantelschicht*' during a certain period of development. This further proliferation of the structural elements of the neural tube is obviously adapted to furnish the material for the later development and completion of the intricate structure of the nervous system as it is found especially in the higher Vertebrates.

6. It is not improbable that these *indifferent cells* may play an important rôle in *regenerative processes* within the central nervous system even in postembryonic periods.

1. *Cranial Nerves of Bdellostoma dombeyi*. (Read by title.)

2. *The Structure of the Organ of Corti in Adult Man*. (Read by title.) H. AYERS.

*The Visual Centers of Arthropods and Vertebrates*. W. PATTON.

It is assumed, based on evidence advanced elsewhere, that the median ocellus of *Limulus* and the Arachnids is homologous with the pineal eye of Vertebrates, and that the lateral eyes of *Limulus* and the Merostomata are homologous with the lateral eyes of Vertebrates. In the Arachnids (*Limulus*), and probably in Vertebrates, the distal end of the median eye stalk contains one or more pairs of medianly fused ocelli. (1) From the proximal end of the eye stalk the median eye nerves separate, and encircling the posterior part of the fore-brain, just in front of the posterior commissure, terminate in *Limulus*, on the hæmal side of the fore-brain, in two great lobes which in

position, form and development resemble the lobi inferiori of fishes. In fishes, amphibia and reptiles two strands of nerve fibres associated with the median eye, and springing from a point just in front of the posterior commissures, extend around the sides of the fore-brain and terminate in the neighborhood of the lobi inferiores. Thus the anatomical relations in both Vertebrates and Arachnids are essentially alike. (2) The lateral eyes of *Limulus* and the related fossil forms, owing to more rapid growth of the hæmal margins of the eye, are kidney-shaped, with the helum directed toward the neural side. This gives the most advantageous and economical arrangement of the ommatidia on the convex surface of the carapace of such animals. If such an eye is infolded and forms a part of the brain, as our theory demands, it will not only be turned inside out, but upside down. The most rapidly growing edge will then, in a Vertebrate, be on the neural side and the retina will be kidney-shaped. Under such conditions, as there is no obvious hindrance to continued growth in that manner, the kidney shape will be accentuated, thus bringing the hæmal margins together and forming the characteristic *choroid fissure* of Vertebrates. (3) Such a view implies that the ancestral optic ganglion of Vertebrates is not a part of the retina, as is often assumed to be the case, but a series of ganglionic lobes similar to those belonging to the compound eyes of arthropods.

In insects where the ganglion is beautifully developed it usually consists of three great lobes: (1) a central one the largest, and shaped like a thick hemispherical shell, in fact, having much the same shape as the compound eye itself; (2) a thick semicircular band extending along its whole distal margin (the retinal ganglion); and (3) a nearly spherical ganglion on its proximal side. The latter is united to the base of the fore-brain by a thick stalk, and each

ganglion is united with its neighbor by decussating bundles of fibres. The medullary portion of each ganglion is mainly on the hæmal side, the ganglion cells on the dorsal. In *Limulus* we have just such a set of optic ganglia, and in the embryos they project far away from the fore-brain and at right angles to it, as in nearly all other arthropods; but they gradually move backwards toward the wide dorsal line till in the adult crab they lie jammed close together on the hæmal side of the fore-brain near the median line.

Now if the migration of the optic ganglia of *Limulus* should continue in the same direction they would cross the median line and, following the path of least resistance, move in opposite directions towards the open space just behind the cerebral hemispheres.

As the proximal end of the ganglion stalk is fixed to the sides of the fore-brain, the ganglion would be bent double so that the stalk and optic nerve would lie parallel and side by side. The whole ganglion would now form the roof and sides of the mid-brain, and would reverse the direction of its curvature to fit its new position, thus effectively disguising its true character. The ganglion by its change in position is partly inverted, turning the ganglion cell layer toward the ventricle and the medullary portion toward the outside, just as the theory demands. In this position the retinal or most distal ganglion becomes the torus longus, the hemispherical one the tectum opticum, the third one the colliculus; the stalk or proximal end of the ganglion becomes the brachia, and probably such other tracts as unite the various lobes with the thalamencephalon; the crossed nerves form the chiasma and the optic tracts, the fibres in both cases entering what is morphologically the distal end of the series of ganglia, *i. e.*, the torus longus and its vicinity. (4) The commissural

systems support such a comparison. *Limulus* has in each ventral ganglion two sets of transverse commissures, four or five bundles below the remnant of the median furrow, and two above it. Thus a rudimentary 'canalis centralis' is formed in the adult with commissures on either side of it. The entire set of neural commissures in the hind-brain of *Limulus* probably represent the beginnings of the cerebellum. In the fore-brain region of *Limulus* are three main systems of commissures, having the same general relation to the brain that the superior, middle and inferior commissures have in Vertebrates.

*Life History and Sexual Relations of the Entoconchidæ.* N. R. HARRINGTON.

The *Entoconchidæ* are a very rare degenerate type of molluscs, first observed by Johannes Müller. Since that observation, in 1852, but one contribution to their morphology has appeared. From the discovery of a new genus of this family, living under new conditions, the following facts may be observed :

1. Ontogenetically these forms do not pass through a Thyca or Stilifer stage, as has been suggested by recent hypothesis. They are ejected through the cloacal wall (as are the Cuvierian organs), or else are eviscerated, escaping from the sac by dehiscence.

2. The larva is free swimming and enters the new host with the water taken into the respiratory system, penetrating either the walls of the latter or those of the alimentary tract.

3. The adult sac is produced by the enormous outgrowth of the genital organs and subsequent degeneration of head parts.

4. For the first time in these degenerate shellless molluscs, separate sexes are observed. The males carry spermatophores. This observation takes *Entoconcha* from the evidence employed to show that Hermaph-

roditism is simpler and more primitive than Gonochorism in the Mollusca.

*Budding in Clavilinidæ.* G. LEFEVRE.

The only genera of this family of compound Ascidians whose bud development has hitherto been described are *Clavilina* and *Perophora*, but the following is a brief account of the process as it occurs in another genus, *Ecteinascidia*. The material was obtained in Jamaica and belongs to the species *E. turbinata*, Herdman. Although in external appearance the zooids resemble those of *Clavilina*, as they are quite elongated and the two siphons are at the anterior end, the species shows a closer similarity to *Perophora*, both in the structure of the adults and the mode of development of the buds. It differs from the former and agrees with the latter in the total absence of an epicardium and abdomen, but is distinguished from these two forms by the presence of perfect internal longitudinal bars in the wall of the branchial sac. There is nothing like the displacement or rotation of the inner vesicle of the bud rudiment, which has been described for *Perophora*.

The ectoderm of the bud is directly derived from that of the stolon and the inner, or 'endodermal,' vesicle from the stolonian septum, which, however, is not a flat partition, but a tube enclosed within the ectoderm and bathed on all sides by the blood. The bud is connected with the stolon at its posterior end, and its long axis is perpendicular to that of the stolon, as in *Clavilina*.

The pericardium is usually the first organ to appear, and is formed by cells which wander out from the wall of the inner vesicle far back on the right side.

The dorsal tube has a similar origin, but arises at the extreme anterior end of the vesicle, while the ganglion is differentiated out of the dorsal wall of the tube.

The sexual organs are also formed from cells which are given off from the wall of