Journal of Comparative Neurology, Vol. II.

Gustav Fritsch.

(See p. 84.)

THE JOURNAL

OF

Comparative Neurology

A QUARTERLY PERIODICAL

DEVOTED TO THE

Comparative Study of the Nervous System.

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VOLUME II.

PUBLISHED BY THE EDITOR.
GRANVILLE, OHIO, U. S. A.
R. Friedländer & Son, Berlin, European Agents.

The Journal of Comparative Neurology

Contents of Vol. II, 1892.

FEBRUARY, 1892.

Pages 1—20, I—IV. Plates I—III.

Literary Notices.

MAY, 1892.

Literary Notices.

SEPTEMBER, 1892.

DECEMBER, 1892.

DECEMBER, 1892. [Supplement.]

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THE CEREBRUM AND OLFACTORIES OF THE OPOSSUM, DIDELPHYS VIRGINICA.

By C. L. Herrick.

With Plates A. B. and C.

Material had been collected over a year ago for a study of the brain of the opossum, but, for various reasons, the completion of the paper was delayed until it now seems best to offer such notes as were collected upon the cerebrum in their necessarily incomplete form. This has seemed the more desirable in as much as this paper forms a portion of a series especially devoted to the histology of the gray matter and commissures of the cerebrum in the several groups of vertebrates and because it in a sense prepares the way for the delayed portion of the rodent paper begun in volume V of this bulletin.

External Form.

In most particulars the brain of the opossum resembles that of rodents, although the relative size of the cerebrum is less than in any rodent type. A larger part of quadrigemina is exposed and the proportions of the infra-rhinalis to the supra-rhinalis portion of the cerebrum is less. In one respect only does the opossum brain approach that of carnivora, i. e. in the possession of an apparent homologue of the crucial sulcus. But there is good reason to doubt the reliability of this homology

The olfactories are relatively very large and are obliquely attached to the crura. They contain, as shown beyond, a considerable mass of cortex upon the pes. Longitudinal sections show a strong medio-ventral fossa filled by a thickening of the pero, especially the glomerular layer. The cavity or rhinocœl is very large and connected with the lateral ventricle by an oval curved aqueductus cruris. The crura are large and exhibit a distinct radix lateralis.

The cerebrum is pyriform with the caudal portions of the hemispheres divaricated. The hemispheres may each be divided both morphologically and histologically into a dorsal and ventral portion separated laterad by the rhinalis fissure and mesad by the splenialis. The portion dorsad of these almost continuous fissures may be regarded as the dorsal lamina or mantle par excellence, while that part beneath contains the ventral lamina and alae. A large part of the ventral portion is devoid of cortex in the usual sense. The dorsal surface is divided into a small frontal lobe, which is circumscribed very deeply from the rest, and a large ovate parieto-occipital portion, which is not subdivided.

The ventral portion is likewise divided into an anterior post-rhinal lobe occupying the region in front of the chiasm and fusing with the crus cephalad, and the large pyriform lobe with its modified cortex. The latter is expanded by the ventral part of the hippocampus into which it passes caudo-ventrad.

The sylvian fissure is not pronounced and does not extend across the rhinalis fissure. A slight longitudinal depression extends longitudinally of the pyriform. This marks the course of the olfactory fibres and limits the non-cortical from the cortical portion. All of the region ventrad is devoid of a genuine cortex. Dorsad of it, the surface is occupied by olfactory fibres as far as to the rhinalis fissure. The mesad surface is separated by the splenialis or calloso-marginal fissure into a dorsal and ventral portion, but this fissure is relatively farther dorsad than the rhinalis by reason of the interpenetration of the thalamus. Cephalad, the rhinalis and splenialis unite and cut off the projecting frontal lobe from the crus beneath.

There is a slight fissure where one might look for the callosal, but in the absence of that commissure it is but the union of the cortex of the gyrus fornicatus with the base. All beneath this fissure is devoid of true cortex and is continued caudad into the septum and corpus fornicis. (See Figs. 3 and 4, Plate A.) The splenialis grows deeper as it passes caudad, following the arch of the hemisphere until it lies in a dorso-ventral line. By comparing the longitudinal sections of Plate B with the transverse series of Plate A, the course of the fissure and the structure of the hippocampus will be perfectly obvious. The commissures are discussed beyond.

The thalamus is about as in rodents.

MINUTE ANATOMY.

Rhinencephalon. The olfactory lobe, as a whole, is of relatively very large size, being expanded in all directions beyond the crus and especially produced cephalo-dorsad. No part of the dorsal part of the pero or cap of the tuber is covered by the cerebrum. The lobe is much larger, for example, than the precrucial lobe of the hemisphere. As seen from above, the outline is ovoid with the larger end caudad and the longer axis passing obliquely caudo-ventrad. The ventral aspect is acutely ovate or subtriangular with the apex mesi-caudad. In its natural position, the infero-cephalic surface is curved and the greater portion is covered by the fibres of origin of the olfactory nerve.

The pero (as this term is used by Wilder) consists of a cap or buskin-like body which entirely clothes the lobe. Its substance extends nearly to the ventricle, which latter is, however, clothed with a larger or smaller mass of white matter with a gray envelope differing totally from that which pertains to the pero proper. Passing entad, we encounter successively the following layers. 1. The fibre layer, which consists of apparently irregularly disposed fibre clusters intercrossing confusedly. Among the fibres are numerous blood-vessels and the usual inoblasts and leucocytes accompany the fibres. 2. The glomerulary layer is of the usual structure; fibres from the cells next to be described pass into the dense ball of neuroglia and emerged clothed with their myelin as distinctive olfactory fibres. It is suggested that the glomerule is simply a locus devoted to the manufacture of the myelin sheaths of the nerves. In this case the only active agents in the process must be the large number of wandering cells or Deiter's corpuscles which congregate about the glomerules in large numbers. If the Deiter's cells have this function here it would be easy to predicate a similar function of the same cells elsewhere. There are many reasons for such an assumption in other parts of the brain. The presence of exactly similar cells in the tracts of medullated fascicles elsewhere is suggestive. (See also Flechsig's' works on the development of the sheaths.) The same explanation may be given for the exactly similar cells in the laminated granular layer. 3. The external neuroglia layer is in this case not distinct from the layer next entad, as the ganglionic layer is dispersed throughout them both. In this respect the opossum differs from any other mammal examined. The ganglion cells are perhaps most abundant near the external boundary of the laminated granular layer, but are irregularly distributed to the very base of the glomerulary layer. The ganglion cells are of pyramidal form and large size with a (generally single) strong apex process which can be traced as a large non-medullated fibre to the glomerulary layer. From the base several processes extend latero-entad or laterad and after penetrating the layers of the granular zone their fibres continue toward the crus. It has not proven possible to determine whether the fibres anastamose and form a reticulum or whether there is one main branch and lateral nutrient roots as claimed in other cases. Our own impression is that there is considerable lateral anastamosis in the neuroglia layers and that fibres after passing into the granular layer soon again acquire medullary sheaths. If, as we believe, the ganglion cells are to be compared with the cells of the spinal ganglia, it would appear that this locus is a point where nourishment is received and hence the myelin sheaths must be interrupted. This space devoid of medullary sheaths is richly supplied with the Deiter's cells which convey the nourishment and also affords the opportunity for intercommunication. The ganglion cells are comparatively large and bear a close resemblance to those of fishes, for example. The nuclei seem to be normally ovoid; but the cells frequently shrink during preparation and this shrinkage especially affects the nucleus.

4. The granular layer is well developed and laminated, each lamina being separated by tracts accumulated from the entad processes of the ganglionic cells. The fibres near the tip seem to pass almost directly through this layer to accumulate at the ventricular surface where they have been considered as forming a part of the pes though actually belonging to the pero. Farther caudad the course of the fibres is oblique. Two different types of corpuscles may be distinguished in these granular laminæ, one being globular and rather larger than the ovoid and darker bodies which we have supposed might be those connected with the function of formation of sheaths for these fibres, while the former would retain the more purely nutritive function.

The pes. Cephalad the ventricular epithelium alone represents the core of the lobus olfactorius. The epithelium resembles that of other parts of the ventricular system. A few connective fibres extend into the granular layer and bear the usual dark inoblastic nuclei. Near the point where the lobe joints its crus the pes develops a different ental structure. Here there is an invasion of cortex from the cerebrum. These cells exhibit no orderly arrangement cephalad, but are irregularly disposed and are pyramidal and deeply staining. The area is triangular, being bounded caudad by the peculiar structure of the post-rhinal lobe, from which it is separated by a distinct fibre tract.

The greater part of this cortex pertains to the crus and may be there considered.

Crus olfactorius. The crus terminates in the pes obliquely, the lateral and dorsal portions being longest. Ventrally it is chiefly made up of the radices of tracts from the pero. There are three such fibre-bundles; the largest, or *radix pedis lateralis*, is an exceedingly strong band, as in rodents. Its development stands in direct proportion to that of the olfactory lobe and this, in turn, with that of the hippocampus. The fibres collect in the granular layer of the pero and then about the ventricle, accumulating chiefly mesad and ventrad. On entering the pes they encounter the invading cortex cruris and are driven ectad, thence laterad superficially to the cortex cruris, where they form a strong bundle passing caudad and somewhat laterad along the fissura radicis to the lobus pyriformis, thence for the most part to cross mesad and entad into the hippocampus, especially the fornicate gyrus. The tract of the fibres caudad is not compact but they spread out to some extent upon the pyriform. The fibres of this ectal olfactory tract are in part overlapped by fibres of a different character.

The *radix pedis mesalis*, on the other hand, is very small and disperse. Its fibres, which arise on the ventral and mesal, as well as especially in the meso-dorsal part of the crus, pass in the neuroglia layer and remain ectad to the cell zone until reaching the neighborhood of the splenialis fissure, where they cross to the gyrus fornicatus. The bundles do not unite to form a single tract but remain largely isolated from each other.

There is no external indication of a *radix pedis intermedius*, but we encounter a few bundles which apparently arise from the ventral part of the crus and passing caudad through the substance of the lobus post-rhinalis emerge mesad and ectad to unite with the bundles of the radix mesalis on their way to the gyrus fornicatus. The fibres enter the peduncular tracts in their dorsad course and pass through them. As indicated above, the dorsal, lateral and mesal aspects of the crus are covered by cortical masses.

Thus far we have been dealing with tracts which undoubtedly pertain to the olfactory pero or ganglion proper. Greater difficulty arises in construing the so called ental olfactory tract (radix mesalis of fishes.) Following suggestions arising from these studies, Mr. C. Judson Herrick has investigated the relations of the cortex cruris to the pero, in rodents. He arrives at the conclusion (Bul. Denison

Univ., Vol. VI,) that there is no direct connection between the tractus præcommissuralis cruris, or internal olfactory tract, and the olfactory substance. On the other hand, the fibres of the tract seem to be largely derived from the cortex cruris and its forward extension into the pes. Of this relation we have been long convinced in the opossum, as well as lower vertebrates, though it would be premature to decide that there is no secondary connection with the pero. A few general considerations might be advanced to indicate the bearing of the conclusion suggested.

1. The olfactory, as a sensory nerve, should be derived from the dorsal part of the primitive medullary tube or embryonic vesicle. According to the above suggestions, such an origin is the only one. The three superficial radices ultimately reach the gyrus fornicatus. Now, if the callosum be considered the partial homologue of the dorsal commissure of the cord, of which there can be little doubt, the cephalic part of the hippocampus, i. e. gyrus fornicatus, is the homologue of the most dorsi-mesal part of the vesicle. The commissura fornicis is also a portion of the dorsal commissural system and the connected parts of the hippocampus are morphologically part of dorsi-meson. The enormous development of the parietal part of the first embryonic vesicle which serves to bring much of the ventral surface dorsad, especially cephalad, causes a revolution correlated with the flextures which obscure the primitive simplicity, but in the rodents and marsupials, it is nevertheless sufficiently obvious.

2. The olfactory, as a sensory nerve, should have a trophic ganglion. This might lie upon the nerve itself, occupying a distinct fossa in the skull, like the Gasserian; it might be carried peripherad and become associated with the end organ, as in the auditory; or it might fuse with the brain itself to form an apparently organic unity. To us the latter seems the actual state of the case. If the tracts are really superficial, lying, for the most part, ectad to the neuroglia layer and, in spite of subdividing into several bundles, reach the same part of the brain; and if the so-called deep olfactory tract or olfactory bundle of the præcommissura springs, like other fascicles of that commissure, from cortex cells, there seems to be no reason for doubting (what is *a priori* so probable) that the adhesion of the pero to the pes is a comparatively subordinate character. In this case, while there may be more or less fusion and interblending of the two, there

is not a morphological but simply a mechanical connection between them.

3. The ganglion of the olfactory, if the latter be a true sensory nerve, should have chiefly trophic functions. There are several hints that the olfactory nerve is trophic. The fact that the fibres of the fifth or seventh nerve may upon occasion supply the place of the olfactory, if authenticated, might be significant in this connection.

4. The structure of the pero, with its large cells, might also be interpreted in this way. The fact that the fibres lose their sheaths in their passage through the pero, but acquire them at either exit seems favorable to this view.

5. The facts of comparative anatomy seem to us to admit of this interpretation. Of course a more careful and extensive comparison of data especially from embryology is necessary before the view thus tentatively suggested could be seriously advocated.

[It may be added that a somewhat extended study of the olfactory radices in lower vertebrates seems to confirm the above suggestions. In several papers in the Journal of Comparative Neurology, for 1891, the writer has shown the essential distinctness of pero and pes and the tracts related. It is especially evident in fishes where a distinct radix lateralis and mesalis relate the one to the pero the other to the pes, the former ending in the hippocampus, the latter entering the præcommissura.]

Callosum and hippocampal commissure. It is not necessary to recount the various opinions and discussions of the callosum in the marsupials. Until Osborn, most authors had agreed that the callosum is absent and functionally replaced by the anterior commissure. Professor Osborn has done much to place this whole subject in its proper light and we agree with him in respect to the essential homologies of the dorsal commissural system. In one group of fishes the callosum is present, as we have endeavored to prove in several recent papers, and is thoroughly distinct from the anterior commissure. The incomplete development of the cerebrum and especially the suppression of the free cortex causes the callosum to appear greatly displaced and it accordingly lies far cephalad in contiguity with the lamina terminalis in front and fornix body behind. We have too much evidence that structures pertaining to the brain when once acquired are not easily lost to be surprised if the callosum in some form exists in all vertebrates. In the case of Didelphys the hippocampus and related structures are strongly not to say predominatingly developed. The motor cortex as such is thrown well cephalad and the fornicate gyrus is carried forward along the mesal surface, as may be seen from an inspection of the transverse sections of Plate A. Thus it happens that the caudal portion of the dorsal commissure system is much more highly developed than the cephalic or callosal portion. The later consists of few fibres which spring from the region about the anterior prolongation of the splenial fissure, if this term may be applied to the fissure which bounds the cephalad continuation of the fornicate gyrus. The separation of the callosum and hippocampus commissure must be ascribed in great part to the folding of the hippocampus and its compression by the contact of the thalamus which leaves but one available path—that persued by the fimbriae. It may be supposed that the cephalad point of fixation of the hippocampus is determined by the fornix bundles, which necessarily enter the corpus fornicis at a nearly constant point. That the fibres belonging to the fornix system are distinct from those of a commissural character was suggested by Stieda and seems quite probable from our observations.

The anterior commissure evidently is the chief coordinating commissure of the frontal portion of the cerebrum.

The easiest solution of the problem of the relations of the calloso-hippocampal commissure with the praecommissura would be to homologize the former with the dorsal, the latterwith the ventral commissures of the cord. Yet the anterior commissure receives fibres from almost the entire surface of the cerebrum.

The Praecommissura. Of the three divisions of the anterior commissure which may be recognized, the so called olfactory portion has been sufficiently discussed in connection with the olfactory. The frontal portion is closely associated with it and these two are together less than the temporal branch. The fibres of the praecommissura hug the ventricles and are perforated by bundles from the peduncles.

Dorsad the commissure is bounded by the very large, nearly quadrangular, body of the fornix. Longitudinal sections of the brain at the median fissure show that the two hemispheres are connected by (1) a delicate membranous tela which springs from the cephalo-dorsal tuberosity of the thalamus and passes cephalad to unite with a conspicuous projection of the lamina terminalis cephalad of the hippocampal commissure and dorsad of the anterior commissure. This connection is not direct along the very mesal line, but here the tela is distended to form a homologue of the dorsal sac of fishes which extend caudad to the epiphysis and is distinct from the aula except along the median line. Its walls give rise to abundant plexus. (2) The hippocampal commissure and fornix body form an oval mass dorsad of the anterior commissure and are attached to it. From the lateral aspects of the fornix body cephalo-ventrad the descending fornix tracts appear. In exactly median sections the fornix body is circumscribed on all sides except ventrad by the ventricle, while the tela springs from a special prominence, but laterad the tela adheres to the fornix body and can be traced to the free margin of the fascia dentata (gyrus uncinatus). (3) The anterior commissure itself is obscurely composed of three portions which are medianly rolled into a compact cylinder. Each has a sheath which can be seen under favorable circumstances. The dorsal and ventral parts are crescentic in section, while the median portion is oval. The dorsal crescent overlaps the ventral cephalad. (4) The lamina terminalis is medianly very thin but contains some gray matter. (5) The callosal fibres are too few to be very obvious in this view.

Dorsal and Ventral regions of the Cerebrum. We think there are good morphological and practical reasons for distinguishing the dorsal and ventral portions of the cerebrum as structures essentially distinct. The limits of the two regions are easily drawn in the opossum. Cephalad the olfactory crus with its cortex is very sharply distinguished from the pre-crucial portion dorsad of it. (Plate A, Fig. 2.) Here the cortex of the ventral portion is very largely covered by the olfactory fibres. Laterad, the two regions are limited, as we proceed caudad, by the rhinalis fissure, mesad the splenial fissure is an equally distinct boundary. Cephalad, these two fissures occupy nearly the same horizontal plane but caudad the former passes ventrad and the latter dorsad, a change which may be ascribed to the interposition of the thalamus. The ventral portion is distinct in cellular structure and presumably in function from the dorsal region. In the former two prominences have their origin, the pyriform lobe of either side caudad. and the post-rhinal lobe cephalad. At the mesal union of the ventral and dorsal regions the hippocampus has its origin as a curious convolution at the splenial fissure. The hippocampus has been carefully described in rodents by C. Judson Herrick in Bulletin Denison Univ. Vol. VI. The relations are still more simple in marsupials and, because of the absence of the callosum, they may serve as a type for comparison. Beginning at a region cephalad of the union of the two hemispheres (Plate A, Fig. 3.) we observe that the cortex at the splenial fissure becomes very narrow and dense and the cells acquire much the appearance of those of the hippocampus. The outer neuroglia layer is thickened and the peripheral fibre zone is collected in small tracts. These tracts, some of the fibres of which may represent the mesal olfactory tract, are thus described in my notes. "A tract which arises ventro-mesal near the crus of the olfactory (exact locality indeterminate) passes caudo-dorsad within the cortex. The several small bundles emerge into the neuroglia zone and before the formation of a deep splenial fissure have attained a position dorsad to it. Thence they pass caudad and are carried entad by the deepening of the fissure and are last seen in the region of the anterior commissure apparently terminating in cells of the uncinate gyrus."

Entad, a strong tract derived from the cells of this region passes meso-ventrad of the tract mentioned, is separated from the corpus striatum by a spur of the ventricle, and is filled with thickly scattered cells. An oblique band of cells passes from the ventricle ventrad toward the meson and seems a continuation of the irregular chain of cell-clusters characteristic of the pseudo-cortex of the ventral region. On the other side of the ventricle opposite the dorsal end of this cell-series is the cephalic branch of the anterior commissure. The limits of the gyrus fornicatus and uncinatus are more or less arbitrarily determined in mammalia. Ranney considers the posterior margin or splenium of the callosum the point where the former passes into the latter. In the present case, however, there being no such guide, we are forced to depend upon morphological modifications of the organs themselves. The gyrus fornicatus arises cephalad by the fold induced by the splenial fissure already described. It may be traced cephalad nearly to the olfactory. The uncinate gyrus is a second fold which appears as the two hemispheres fuse. (Plate A, Fig. 4.) The free dorsal margin is outwardly folded and at the same time "faulted" by being slid somewhat laterad as if by the agency of the thalamus wedged between the hemispheres. The fornicate and uncinate gyri are curved in opposite senses and related to each other somewhat as are tiles on a roof. In speaking of the uncinate gyrus as the free portion of the median cortex it must be understood in a limited sense, for the mesal margin passes into the plexus and tela and ultimately forms the connection with the roof of the thalamus. The splenialis fissure grows deeper and curves ventrad, finally curving ventro-mesad (Plate A, Fig. 5.). Meanwhile, the medullary fibres of both the fornicate and uncinate gyrus accumulate to produce the cephalad parts of the fornix. The relations remain nearly the same throughout the posterior parts of the cerebrum though the curvature of the hippocampus about the thalamus causes the transverse sections to fall in other planes. The longitudinal sections of Plate B show that the relations between the two gyri are maintained to the very subiculum.

The cellular structure of the hippocampus bears out the distinctions already made. The cells in both are densely clustered and form practically but a single series. The peripheral processes are from the apices of the elongate fusiform or spuriously pyramidal cells. The entad extremity is frequently almost equally prolonged. The nuclei are large and clear. The cells of the fornicate gyrus are nearly twice as large as those of the uncinate and the latter also lie in a different plane, a fact due to the faulting or rotation of the gyrus as a whole. The structure of the hippocampus and its great complexity in other mammals is due chiefly to the flexture and caudad thrust of the callosum.

For a very complete historical account of the hippocampus and related structures see the works of Honegger [1] while the most recent work on the histology is that by Sala.[2]

After the painful attempt of Honegger to bring into harmony the infinitely diverse nomenclature of this subject we can but feel that a strict morphological terminology best meets the case. Embryology and comparative anatomy leave no doubt that we are dealing with two folds of the caudo-mesal cortex which are simply plicated and then curved upon each other. One margin of the structure is connected directly with the occipital cortex, the other with the tela and proplexus. The mesal convolution is the fascia dentata or gyrus uncinatus produced, the lateral convolution is the gyrus fornicatus. The alveus is the ental fibre zone of the gyrus fornicatus and the fimbria is the transition of the alveus into the fornix and hippocampal commissure.

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[1] J. HONEGGER. Vergleichend-anatomische Untersuchung ueber den Fornix und die zu ihm in beziehung gebrachten Gebilde im Gehirn des Menschen und der Saugethiere. Genf. 1890.

[2] L. Sala. Zur feineren Anatomie des grossen Seepferdefusses. *Zeitschrift fue wissenschaftliche Zoologie.* LII. I. 1891.

That portion of the cortex within the gyrus fornicatus is the stratum griseum circumvoluta of authors. The ectal tract of this convolution is the so-called lamina nuclearis. Meynert, with his usual morphological insight, recognized in the fascia dentata the free margin of the mesal portion of the manth. These relations are especially well seen in Plate XVII. of Honegger's work. As Sala says, the sole difference between these gyri and other parts of the mantle consists in the fact that the cells are crowded into a single narrow layer. With the statements of Sala respecting the histological relations we are unable at present to agree. 1st. That author describes the cells of the fascia dentata (gyrus uncinatus) as splenial. We think that, when the cell body is preserved, it differs from those of the gyrus fornicatus chiefly in size, but it lies in a different plane. We are furthermore unable to discover how the distinction between the protoplasmic and nerve process is made out in cases where they are so similar. 2d. Sala states that the large cells of the gyrus fornicatus are functionally connected with the fibres of the alveus, while the apical processes subdivide interminably and terminate in the processes of neuroglia cells. The nervous processes may spring from either end of the cells and either pass directly entad to the alveus or ectad to the fibre layer immediately adjacent and then return to the alveus. If the evidence of our sections is to be trusted, the apical fibres pass directly into the ectal tract while the opposite extremity of the cell subdivides dichotomously, producing such a neuropilem as Sala himself figures, with which the alveus fibres may communicate.

It seems scarcely to be doubted from the course of the radix lateralis that its fibres reach the surface of the hippocampus and connect either directly or indirectly with the ectal layer of this region. The great mass of the alveus fibres are derived from the ental aspect of the fascia dentata. Thus, according to our view, the lamina nuclearis and superficial bundle of the fascia dentata are parts of the tract from the radix lateralis. Strong confirmation of this suggestion is found in the much simpler relations in fishes. (See forthcoming paper in Journal of Comparative Neurology for December.)

THE CEREBRAL CORTEX.

The cortex of the precrucial lobe may be regarded as typically motor, but even here there are many cells of the ectal series which divide at once into two or more strong processes and these in turn again divide dicotomously until a dense felting of fibres develops over the ectal layer. Into this felting pass the apical fibres of the pyramids of the smaller size or ectal series. It is not easy to trace the ultimate course of these fibres, but in some cases, at least, they obviously divide into two and are lost in the neuropilem above referred to. Beneath the small pyramids at a variable distance is an ill-defined layer of larger pyramids whose apical processes seem also to pass into the neuropilem. Still entad of the giant pyramids are the usual multipolar cells adjacent to the white mater or fibre zone. More or less frequent in all of these layers, but especially entad, are large clear granular nuclei surrounded by unstained spaces which may represent the bodies of unstained cells of the aesthesodic type. In cases where the cell-body is stained it almost invariably has the apical process directed entad. The average length of the body of the small pyramids is about .03 mm., while the giant pyramids are more than .04 mm. exclusive of processes.

The cortex of the crus, i. e. of the lateral aspects of the cerebrum below the rhinalis fissure is the same as that of the ventral part of the cortex farther caudad.

Longitudinal perpendicular sections exhibit little difference between the cephalic and caudal portions of the dorsal cortex although the latter portion seems to possess proportionally more of the second type of cells.

In a section of the parietal region the neuroglia layer consists of an outer less densely stained layer and an ental layer which latter is suffused with stained matter evidently of an albumenous character. The inner layer may be called the ectal neuropilem zone because of its being filled with the finely dividing process of layers within. The anastamosis of these fibres, while very probable, has not been observed.

The cellular elements in this layer are inoblasts of connective fibres and Deiter's cells. Beneath the neuroglia is a band of cells forming the ectal portion of the cell-bearing cortex. The cells are small pyramids in part but a careful study shows that there are many cells of a somewhat different character, i. e. the peripheral process is not simple but branches dichotomously and then subdivides into a fine fibrilary felt. Immediately above and about this layer the felting of fibres is most dense and results frequently in a diffuse coloration rendering observation difficult. Beneath this layer there follow successive layers of small pyramids with some fusiform cells. The fibres from the apex in each case is continued to the ectal neuropilem zone there dividing to mingle with the previously described fibres. The basi-lateral processes (there are no axial basal processes in the sense implied by Meynert) subdivide and form a diffuse mesh-work or felting which is nowhere concentrated to form a definite zone. Although it cannot be considered certain, it nevertheless seems probable from the appearance of the sections that these processes become associated indirectly with the cells next to be described.

The median and deeper parts of the cortex are everywhere, except in a few isolated motor nests, sprinkled with cells of a very different appearance. The cell-body scarcely stains with mercuric hematoxylin but the nucleus is brought out distinctly without being rendered opaque. The latter is large, often quite as large as the diameter of the smaller pyramidal cells. The contents of the nucleus are granular. The area about the nucleus may be vacuolate or the somewhat shrunken fusiform or irregular cell body may be sufficiently stained to be detected with care.

In a great many cases it is possible to trace the basilateral processes of the large pyramids to the immediate vicinity of these cells where they seem to form a loose reticulum.

The pyramids almost uniformly have near their bases one or more small dark nuclei such as we have called Deiter's bodies. The regions of the cortex near the white fibre zones are filled with multipolar cells with several basal and one peripheral process as the rule.

Histology of the ventral part of cerebrum. Fig. 1, Plate B illustrates the appearance of a horizontal section taken ventrad of the union of thalamus and hemisphere. Three distinct portions are presented; cephalad the large olfactory lobe with quadrangular outline and large ventricle. The pero is evidently separated from the pes by a ganglionic layer. The lobe obliquely applied to its crus so that the median surface extends much farther caudad than the lateral. The radix lateralis appears as a thick tract passing directly caudad to the pyriform lobe. The crura are long and connect with the ventro-median projections which we have called post-rhinal (or ventro-median) lobe. (The olfactory region is described in detail above.

The post-rhinal lobe is largely covered superficially by olfactory fibres. Entad to this are irregular clustres of cells and dense aggregates of Deiter corpuscles in opaque patches of neuroglia. The cells are of the type which we have termed rhino-morphic, i. e. are small irregular pyramids. Fig. 10, Plate A illustrates such cells upon the confines of a clustre of Deiter cells. Within the cortex there are irregularly disposed sensory cells. It will be observed that the postrhinal lobe lies in or near the anterior perforated area. Comparing the mammal brain with that of Sauropsida, it seems legitimate to conclude that these sharply localized clustres of corpuscles correspond to the proliferating areas of the axial lobe of the reptiles and birds. The presence of great numbers of vessels is essential for this purpose. The opaque color of the region in which the corpuscles are imbeded may be accounted for by the supposition that albumenous matter is collected about the proliferating centres. May it not be that those cells which are so uniformly associated with the large end of the pyramid cells of the cortex are derived from this or some similar source? In this case, we have a novel modification of phagocytosis in the brain.

In the caudad portion of the post rhinal lobe, especially ventrad, the cell clustres and granular areas are especially numerous. The third portion of the section consists of the pyriform lobe, which at this level is similar in outline and size to the olfactory. The laterad, caudad and mesad are provided with a strong sub superficial zone of cells to be described more at length beyond but there is also a considerable admixture ventrad and mesad of the rhino-morphic cell type. In the central part of the pyriform lobe are numerous clustres of Deiter cells within clear spaces of the neuroglia, reminding one of those clustres or rosette-groups of cells found in similar regions of birds and reptiles.

The cortex of the regions ventrad of the rhinalis fissure has a habitus of its own. Immediately beneath the neuroglia layer the cortex is densely massed with only sparse pyramidal cells scattered entad without the stratification encountered in the dorsal cortex. The cells of the superior dense layer vary astonishingly in form, some being regular pyramids while the greater number are multipolar with numerous processes which pass into the neuroglia zone and there break up into a fine reticulum or felting of fibres which cannot in these sections be seen to anastomose or to enter the superficial tracts (radices of olfactory or otherwise). The deeper cells are chiefly pyramids and are frequently so isolated as to appear beautifully distinct. (Fig. 7, Plate C.) The apical process is generally peripheral and can be traced into the neuroglia zone where it can be seen in many cases to break up into numerous fine branches. The cell body is elongate pyramidal with numerous lateral and basilateral branches which subdivide and weave themselves into the reticulum in which they lie. In only a few cases have actual anastomes been observed. The nuclei are large and elongate and there is a marked tendency for small corpuscles to associate themselves about the base between the spreading branches of these cells.

In some cases, especially toward the ental fibre layer the pyramids are reversed and the apex process passès centrad. Near the contact with the white matter the cells are rather multipolar than pyramidal and their chief process appears to pass into these fibre tracts. The white fibre layers at the surface in this region seem to be derived from the radix lateralis of the olfactory. Longitudinal sections seemed to indicate that the lateral radix divides or other fibres become associated with it, at least a band of obliquely-cut fibres may be seen ectad to those are passing directly caudad. The latter portion is thought to pass obliquely over the median surface to the hippocampus while the ectal portion seems to spread out in diminishing quantity upon this region The vast quantity of fibres overspreading this region (i. e. lateral and ventral part of pyriform lobe) seems to preclude the possibility of all having been derived from the radix lateralis. The ventral regions of the pyriform exhibit pyramids mingled with large multipolar or fusiform cells with large clear circular nuclei. In some cases it seemed probable that the axial processes of the pyramids first described suddenly turn as they reach the neuroglia layer. In other cases and in the case of the superficial multipolar cells the is no doubt that the processes subdivide very minutely. This region of the neuroglia is so filled with non-medulated fibres as to stain more deeply than other regions. We seem here to have a neuropilem in the sense suggested by Koelliker.

In the infra-rhinal type of cortex strands of fibres may often be seen passing from the ectal nervous reticulum between the cells toward the central white matter. This is especially apparent at the caudal extremity of the pyriform lobe.

Cortex of Occipital region. In the lateral aspect of the occipital region dorsad of the rhinalis fissure we encounter a commingling of two distinct kinds of cells. The pyramidal cells are present over most of the cortex, being most numerous peripherally. They can be recognized by the deeply stained elongate nucleus and form of the cell. The second class consists of cells of a fusiform or pyriform (i. e. flask) shape. With the selective stains used, haematoxylin and $Hg\ Cl_2$, the nucleus alone stains in most instances and this not deeply. A reticulum within the clear nucleus is brought out, but, as a rule, no distinct nucleolus. Where the cell contour is visible it is as described above. Such cells are associated with the deeply stained pyramids in such a way as preclude the view that the difference could be duc to varying treatment.

The distinction once relied on by us, i. e. the direction persued by the apical process does not seem constant here. The deeper cells have the apical process directed entad while the ectal series may have the reverse position. The dorsal portion of the occipital region is occupied by these flask cells almost to the exclusion of all others. In longitudinal section at the poserior part of the cortex the following observations were made. There are here few pyramidal cells and a relatively large number of pale cells which contain large clear nucleoli and chromatin (?) mesh-work. The cell body is frequently so inconspicuous as to make the nuclei appear like free corpuscles. In many cases sufficient care will detect the cell outlines and in other spaces in the neuroglia testify of their presence. The outline of the cell is rarely as distinctly pyramidal as in the motor type through peripheral processes in some cases at least pass dorsad. See plate C, Fig. 6, which is a drawing of a portion of the occipital region (IV—7.) as seen with the one-fifth inch objective. *m.* is one of the pyramids and *s.* one of the supposed sensory cells. The almost constant presence of Deiter's cells at the base of the pyramids will be noticed. This region may be contrasted wit a typical motor area as drawn in Fig, 1 of the same plate or Fig. 2. A mixed area some distance beneath the ectal layer of cortex is drawn in Fig. 11, Plate A. In this case the sensory cells are almost unstained except the nucleus. (4—14.) In even the typical motor regions these pale cells are always present though in less numbers and mostly crowded to lower levels. Toward the posterior part of the hemispheres the cortex along the middle of the lateral aspect differs quite obviously from any other portions. The band is rather narrow and consists of small and slender cells which are in many cases pure fusiform elements, others are flask-cells, or rather inverted pyramids, but careful examination with one fifteenth inch objective (1500 diameters) shows that the process directed proximally does not form a single axis cylinder, as appears at first, but dissolves into several small fibres. Among these cells are a few with the usual pyramidal structure, but more slender than usual. Near the white matter are large cells which change their direction to correspond with the direction of the tracts. This lateral area may have other functions than the dorsal or ventral area, but what the functions difference may be it is impossible to conjecture.

The motor regions of the cortex are illustrated by Figs. 1 and 2, of Plate C. Fig. 1 is a drawing made to a scale illustrating a strip of cortex extending from beneath the giant cells nearly to the upper cell layer. The region is in the fronto-dorsal cortex near the median fissure. The two drawings are part of the same strip of cortex, the right end of No. 1 being near the dorsal surface. The forms vary considerably, some of the cells being simply fusiform, others inverted pyramids while there are a few æsthesodic cells among them.

Fig. 2, is a camera drawing of the cortex from the deep pyramids to near the ectal layer. The apex processes extend beyond the cortex. The process of nutrition of the pyramids suggested elsewhere is well seen here. Several of the carrying corpuscles are often seen at the base of one pyramid. Fig. 4, Plate C, is a camera drawing of a few of the deep pyramids or giant cells under the one-fifteenth objective.

The general conclusions growing out of this investigation are briefly as follows: There is in the opossum a decided difference between the aesthesodic and kinesodic cell types. Regions known to be sensory contain a large number of the type with clear round nuclei. The delimitation of the areas is, however, very incomplete. This agrees well with the results of experiments. The two classes of cells are rarely unmixed in any area. In many cases at least the cortex cells give off processes which divide in the so-called neuroglia layer to form either a neuropilem or reticulum. It would seem that a more or less connected reticulum of fibres directly supplied by the cells is the simplest anatomical device which can in any way be associated with unit states of consciousness.

The probem of nutrition of the specific nerve cells is, we believe, somewhat simplified by the suggestion that there are special proliferating centres in the brain base in which there are produced numerous corpuscles like Deiter's cells which then migrate to the cortex and convey nutriment to the cells. The small and frequently shrunken bodies at the bases of pyramidal cells are interpreted as such nutrient bodies from the sources indicated, one of which is the post-rhinal lobe near the substantia perforata anterior. With reference to the fact that the cells regarded as kinesodic generally have their apical processes directed peripherad (the converse being the case with the æsthesodic,) it must be said that too much confidence should not be placed in this distinction. We now believe that the direction of the apical process is to be interpreted as a function of the direction from which the cell has migrated. We have shown in a series of papers that there is morphological and embryological evidence that the cortical cells are not formed in situ but have migrated from proliferating areas primarily found in the axial lobe. This suggestion has recently been greatly emphasized by the discovery that the axial lobe of fishes contains well marked areas of the two kinds of cells sustaining the proper relations to the tracts to enable us to identify them as motor and sensory respectively. It is believed that the motor areas of the cortex are supplied by cells which migrate from before backward and first lodge in the cortex, whence many subsequently migrate to deeper zones. Such migrating cells retain their connection with the peripheral source by means of the long apical processes. Sensory cells, having in many cases a different path of migration, naturally occupy different positions. In view of the recent results of Golge's method of staining, it would be premature to decide how far these processes are simply nutritive and how far actually nervous. It is significant, however, that the processes of nutrition apparently go on at the base of the cell as indicated by the nutritive nuclei there collected.

PLATE A.

A series of transverse sections through the cerebrum of the opossum.

Fig. 1. Section through the olfactory lobes.

Fig, 2. Section at the junction of the crus and post-rhinal lobe near the union of the rhinalic and splenial fissures.

Fig. 3. Section through the fore part of the cerebrum.

Fig. 4. Section through the anterior commissure and fornix body.

Fig. 5. Section at the caudal part of the anterior commissure, showing the encroachment of the radix lateralis mesad and the dorsal sac.

Fig. 6. Section through the præthalamus and chiasm

Fig. 7. Section through the mesencephalon at the posterior commissure and hippocampus.

Fig. 8. Section through the occipital portion of the cortex and nates.

Fig, 9. Section through the cerebellum and pons.

Fig. 10. Portion of area of the post-rhinal lobe [region of Fig 3a,) embracing a portion of one of the granular masses as well as of the rhinomorphic cells.

Fig. 11. Portion of a section of the dorsal cortex near the meson. The figure embraces a region near the surface and shows two kinds of cells. The apex processes of the motor pyramids are very long, extending to near the upper level of the cortex, while the cells of the second type have the cell body almost unstained.

Fig. 12. Cortex of the mesal surface near its ventral limit. The mesal olfactory tracts are here breaking through the cortex. The position of the cells is disturbed and the apical processes dip out of the section. The surface is at the right.

PLATE B.

A series of eight horizontal sections through the entire brain beginning ventral and passing cephalad of the anterior commissure.

Fig. 8. A horizontal section through the superior commissure.

PLATE C.

Fig. 1. Portion of the cortex from the dorsal surface near the median fissure, extending as far entad as the giant pyramids. (Slide 28.) The cells are chiefly motor pyramids.

Fig. 2. Large pyramids of the parietal region, from a horizontal section. Camera drawing with one fifth inch objective.

Fig. 3. Ectad pyramid cells from præcrucial lobe near the median line. Camera drawing with one-inch objective.

Fig. 4. A few pyramid cells from the dorsal cortex drawn with one-fifteenth inch objective and camera. Observe the nutrient cells at the base in each case.

Fig. 5. Typical sensory cells from near the base of the cerebrum.

Fig. 6. Portion of the occipital cortex showing the two kinds of cells.

Fig. 7. Portions of the lateral cortex ventrad of the rhinalis fissure and beneath the olfactory fibre zone. The neuropilem above lies just entad of the radix laterals tract.

Fig. 8. Cells from the hippocampus at Fig. 5a, Plate A, showing the relations of the processes of the cells of the gyrus fornicatus to the ectal tract.

ERRATUM.—Page 12, line 11, for *splenial* read *spherical.*

LITERARY NOTICES.

COMPARATIVE PSYCHOLOGY.

Our title indicates a science yet to be created, but one for which materials are rapidly collecting and methods formulating. The importance of an adequate interpretation of the supposed mental activities of animals other than man has been fully recognized by the most fertile and resourceful students of the century, among whom may be mentioned Darwin, Wallace, Lubbock; Romanes, and Eimer, while Mueller and, in our own country, Peckham and McCook have industriously and intelligently added to the accumulation of materials.

Of all the discussions of the general subject of animal inteligence the most lucid and even luminous work is that recently published by Professor C. Lloyd Morgan, Dean of University College, Bristol. [1] Some points in the author's treatment will be commented upon more at length beyond. It may be said here that in clearness, honesty and charm, the author's style compares favorably with that of his acknowledged master, Charles Darwin. His facility in happy phrase lends piquancy to a treatment which presents clearly and without fatigue even the most abstruse aspects of the subject.

It would be useless to discuss the question which will inevitably be raised in some quarters, Is not comparative psychology a contradiction of terms? We know of the supposed states of consciousness of animals exactly as we learn of those of other human beings, by inference based on our own conduct while conscious of certain states and, if it be true that the activities of animals bear unmistakable resemblance to our own conduct under definite states of consciousness, it is scientifically legitimate, nay, imperative, to critically examine the nature of such resemblances, quite irrespective of any theory or postulated difference between man and beast.

If it be true that some of our nervous processes are more closely correlated with more complex states of consciousness than others, it would be assumed, from the grand achievements of the comparative method in other departments of science, that a comparison of the nervous processes of animals with those of man would be most useful in exclusion of what is irrelevant and construing the residua. Whether or not one is prepared to believe with Professor Morgan that every neural process or neurosis is not merely associated with, but is the reverse aspect of a psychical process or psychosis, every one is interested profoundly in discovering how far one influences the other directly or by way of heredity, and no way is more likely to lead to satisfactory results than a sudy of subjective processes in the light of comparative observation and experiment.

It is needless to say that one's mental equipment for such work should be of the broadest, but this fact need not deter one from the accumulation of data and

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[1] Animal Life and Intelligence. Boston, Ginn & Company. $4.00.

some attempt to examine critically the accumulation. We further claim that no line of research is better adapted to produce the particular mental discipline required by a student of nature than the attempt to interpret (under careful guidance) such phenomena as those of animal intelligence. The dispassionate attitude possible in a field somewhat apart from the well-trodden arena of historical philosophical debate is not the least of the advantages.

We predict that the time is not far distant when many of our universities will offer extended courses in Comparative Psychology, where Physiological Psychology as usually limited will constitute but a coherent portion of a systematic study of the phenomena of psychosis and neurosis throughout the entire animal kingdom. The expression of emotion and physical foundation of proclivity, desire, and choice will be investigated by minute verbal and photographic record under the most careful experimental control Camps will be formed in the wilderness for the express purpose of studying natural expression and instinct where camera and note-book may supplant rod and gun. The laboratory will contribute the most detailed study of nerve paths and connections, seeking to explain where possible the physical laws of associated motions. Experiment will ivestigate the complicated interplay of inhibitory and stimulating discharge in the cells of brain and cord. But all of these will be combined and co-ordinated under the direction of the data of consciousness so that all may contribute positively or negatively to the edifice of a true psychology.

Returning to the volume which suggested these reflections, the first portion is in reality a brief course in theoretical Biology, covering in 240 pages such subjects as the relation of the animal to the environment, vital processes and their analogies, reproduction and development, variation, the law of increase, elimination and selection, protective resemblance and mimicry, isolation and segregation, divergence and convergence. heredity, pangenesis, continuity of the germ-plasm, panmyxia, origin of variation, etc., etc.

These difficult topics are discriminatingly and conservatively handled so that the discussion forms an admirable introduction to the works of Weismann, Wallace and Cope. (Parenthetically we might remark that, while recognizing the feebleness of Wallace's attempt to explain the origin of sexual coloration and the like as a result simply of a superabundance of vitality which spontaneously effloresces in plume and pigment, the author does not discuss the obvious substitnte for it, viz: Unusually perfect and highly vital individuals will exhibit unusually great excitement, and, as it has been shown that the cranial nerves have an intimate association with the skin especially of the head and neck, it is quite probable that this superabundant excitement will exhibit itself in reflex modifications of comb, coloration, etc. But such highly organized individuals will tend to reproduce themselves, not because of the coloration but by virtue of the vitality expressed by the colorotion. Again, the antics of the male bird or insect may be but an expression of the intense excitement which may have been a simple reflex at first, but, by the selection of most excitable individuals, has become an hereditary instinct.)

The chapter on the senses of animals covers acceptably familiar ground, but it is in the remaining portion of the work relating to mental processes in animals and man that the author's mastery of thought and style are most obvious.

Impressions are the bricks in the house of knowledge. A certain amount of mortar (cognition and recognition) is supplied by the builder. A sensation is an impression that has been discriminated from others.

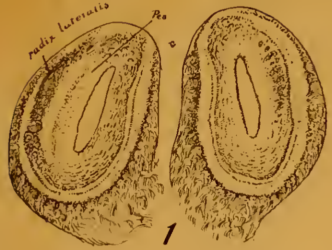
Objecting to the familiar simile "eye-gate," "ear-gate," he says: A much closer analogy is this: Something stands without and knocks at the doorway of sense, and from the nature of the knocks we learn somewhat concerning that which knocks."

At first one is inclined to quarrel with the coinage of new terms for familiar ideas, but becomes reconciled to "construct," "predominants" etc. on the ground of unambiguity. The felicities of the diction even in intricate discussions are illustrated by the following. "In ordinary speech, when we pass and repass from motives to actions and from actions to feelings they may give rise to, we are apt to be forgetful of the depth of the chasm we so lightly leap. And this is no doubt because the chasm, though so infinitely deep, is so infinitely narrow" The whole discussion of habit and instinct is admirable.

In the origin of instinctive activities he recognizes three factors. 1. Elimination through natural selection. 2. Selection through preferential mating. 3. The inheritance of individually acquired modifications. In all three, intelligence may or may not have been a factor.

The author concludes this topic with the statement that without inhibition, volition properly so-called has no existence and, by distinguishing the perceptual volition of animals from the conceptual volition of man, prepares the way for the interesting chapter on mental evolution. This subject would carry us too far, but the position taken is concisely expressed in the following sentence. "Parallel to the evolution of organic and neural kinesis there has been an evolution of metakinetic manifestations culminating in conscious thought." "Phenomenal reality has two aspects—an inner aspect as metakinesis, and an outer aspect as kinesis." "What are for me states of consciousness are for you neural processes in my brain."

At one point—the discutsion of the ego does the discussion, as it seems to us, leap the track and one holds his breath for the crash that must ensue. It is possible that some readers may refuse to follow the argument beyond this point, but they will be well paid by the suggestive if not entirely convincing discussion of the selective influence of metakinetic activities inter se and the law of congruities.



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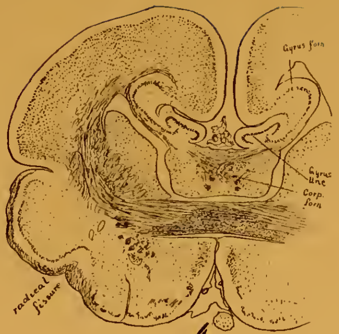

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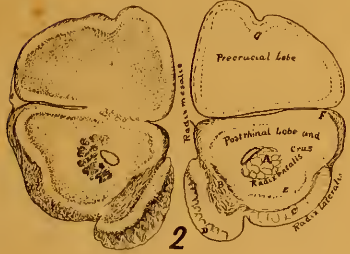

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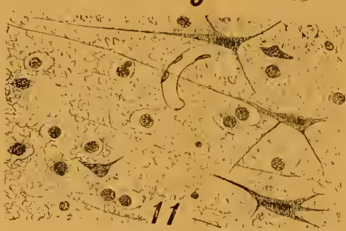

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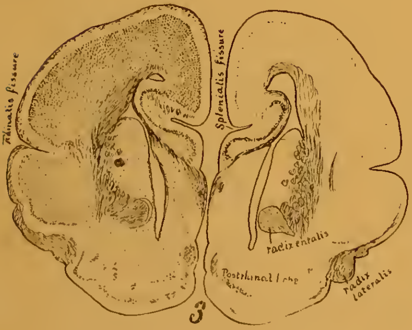

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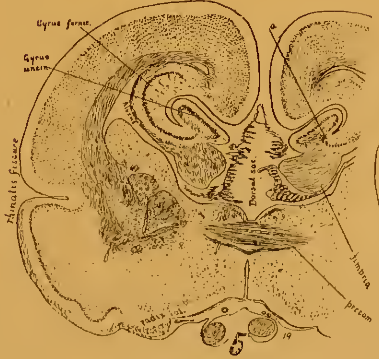

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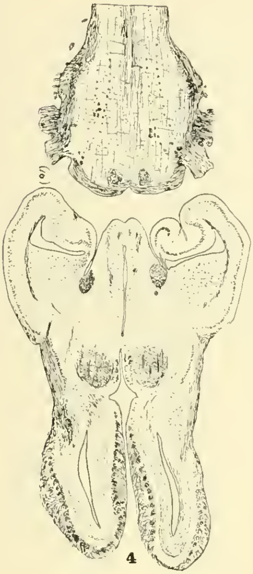
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Pons
postrhinalis lobe

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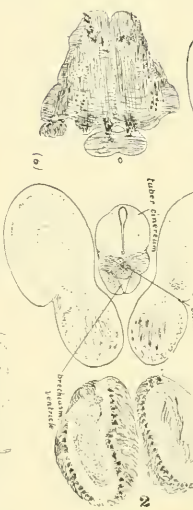
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o
tuber cinereum
Chiasm
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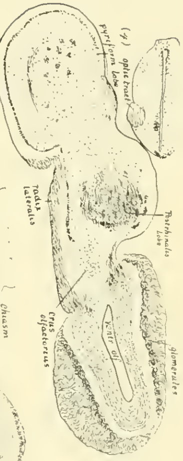
(4) optic tract
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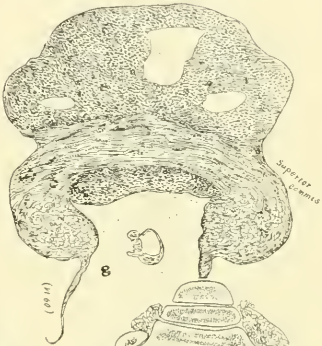
Radix lateralis
Postrhinalis lobe
Crus olfactorius
Ventr olf
glomerules

1


Superior commis
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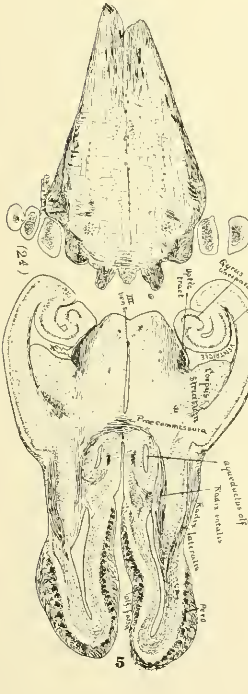
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III ventr
Optic tract
Gyrus uncinatus
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aqueductus olf
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Radix lateralis
olf. lob
Pero

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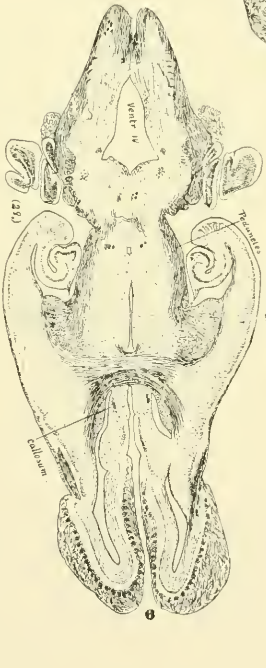
Ventr IV
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Peduncles
Callosum

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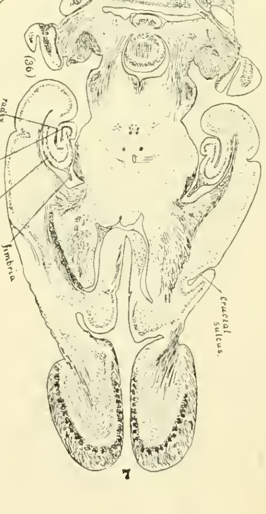
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radix lateralis
fascia dentata
alveus
fimbria
Crucial sulcus

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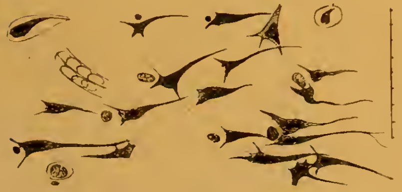

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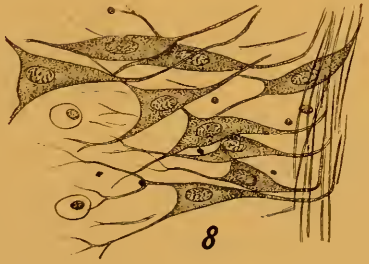

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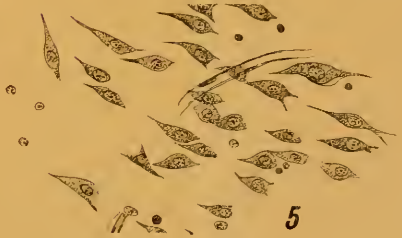

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CONTRIBUTION TO THE MORPHOLOGY OF THE BRAIN OF BONY FISHES.

II.—STUDIES ON THE BRAIN OF SOME AMERICAN FRESH-WATER FISHES.—Continued. With Plates IV—XII.

C. L. Herrick.

C.—Histology of the Diencephalon and Mesencephalon.

The present instalment of this paper is based upon a considerably increased material, including a number of series of European fresh-water and marine forms, in many cases the same species which have been used by the pioneers in this field. Considerable embryological material has also become available from which it is hoped to derive additional facts in a later instalment. In consideration of the obligation imposed by the possession of a variety of material probably never before available for this purpose, the writer has endeavored to exercise all care possible in the statements made. Considering the difficulty attending this region and the fact that our ablest anatomists differ fundamentally in such important matters as the origin of the optic nerve, absolute accuracy is out of the question. It appears unquestionable, however, that the brain of Teleosts is the proper quarter in which to seek the solution of the very important problems respecting the fibre paths in the mid-brain. It is in this case simply a question of sufficiently numerous and complete series, for one can trace fibres to cells in a way impossible elsewhere. Enough is indicated in this paper to prove that in all essentials the fish brain is constructed on the same plan as that of higher animals and, if the suggestion of minute homologies with mammalian organs seems audacious to those who recall that living authorities are not agreed as to which part of the brain represents the cerebrum and whether or not there is a real corpus quadrigeminum, yet we trust that everyone who will take the trouble to carefully look through series of sections of fish brains will recognize at least the resemblance of structure and similarity of position. While the employment of such terms as frontal lobe, occipital lobe, etc., in the previous instalment was with the definite understanding that these expressions were descriptive and not intended to express homologies, in the present case it is generally proving possible to use terms for organs which are regarded either as rather strict homologies of those in man or equivalent in some true sense. Of course such structures in the human brain as are recognized by virtue of their external configuration only can have no homologues in fishes.

Considerable time has been devoted to the search for methods better adapted for the purpose of this work, but thus far nothing has given as satisfactory results as the chromacetic solution recommended above. For certain purposes the staining with acid fuchsin after or with hæmatoxylin seems advisable, as it assists in differentiating the connective elements. As an adhesive, a solution of photoxylin in chloroform seems to promise well, but a mixture of egg albumen and 2—3 parts of glycerine does not discolor so much as to seriously affect the usefulness of the sections, much as it interferes with the beauty of the slides. (In giving the fusing point of the paraffin employed, p. 338, above, "50 deg. C." should be substituted for "30 deg C.") A method which promises well for the treatment of ribbon sections is to float the bands out upon warm water somewhat below the fusing point of the paraffin. After cutting to the desired length the bands are lifted out on the prepared slide and allowed to dry before the paraffin is fused. Much care is required, but if successful, the wrinkles which destroy the usefulness of very thin ribbon sections may apparently be thus avoided.

The complicated character of the subject and the difficulties of a lucid treatment must not be underestimated. The effort to combine the scattering descriptions of previous writers warns the author that he cannot hope to escape obscurity and diffuseness. Headings are prefixed which may aid somewhat in finding what is desired and an index of terms at the close may assist in comparing our results with those of the pioneer authors, though absolute uniformity has not been attained.

It may be useful to prefix the following

OUTLINE.

I.—*Additional remarks on the histology of the hemispheres.*

II.—*Tracts from the hemispheres.*
  1. Tænia thalami (?)
  2. Dorsal peduncles.
  3. Ventral peduncles.
  4. Fornix and basal prosencephalic tract.

III.—*The præthalamus and tuber cinereum.*
  1. Niduli of præthalamus.
  2. Tuber cinereum and tract to ventral commissure.
  3. Mammillaria, post-cinerea, and conus præcommissuralis.
  4. Hypophysis and saccus vasculosus.

IV.—*The interoptic commissures.*
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  2. C. transversa.
  3. C. minor.
  4. C. horizontalis.
  5. C. superior tuberi.

V.—*The dorsal region of the thalamus.*
  1. Epiphysis and dorsal sac.
  2. Habena.
  3. Meynert's bundle.
  4. Nidulus corticalis and posterior longitudinal fascicle.

VI.—*Optic nerve and brachii.*

VII.—*Tectum opticum and its tracts.*

VIII.—*The nidulus geniculatus externus.*

IX.—*The colliculi.*

X.—*The pes pedunculi.*
  1. The hypoaria.
  2. Nidulus ruber (rotundus) and nidulus niger.
  3. Connections with cerebellum.

XI.—*Nidulus subthalamicus and central gray matter.*

XII.—*The pons, middle peduncle of cerebellum, and commissura ansulata.*

I. *Additional remarks on the histology of the cerebrum.*

A careful examination of our sections fully substantiates the description of the relation of the olfactory radices in all the species at our disposal. In a brain of a very young *Amiurus*, which by accident had been so obliquely cut that the plane of section coincided with the curvature of the radix lateralis, the entire course could be seen in a single section and it was, furthermore, evident that no fibres were or could be given off between the pero of the olfactory tuber and the hippocampal nidulus, as there was a definite boundary on the dorso-lateral aspect. The radix lateralis is therefore a distinct and direct tract of the pero. Moreover, careful examination with oil immersion lenses showed that the fibres of the radix mesalis terminate in cells of the pes; i. e. in the small fusiform cells which form the axis of the tuber. The evidence seems therefore to be complete not only that these fibres have a different central destination, but that they arise in distinct parts of the tuber and have nothing in common. If the pes olfactorii be regarded as a prolongation of the basal part of the prosencephalon, the radix mesalis (entalis) is simply a special part of the præcommissura.

A comparison of European fishes shows that here too the regions in the cerebrum described above are obvious internally if not externally. To describe all the slight variations encountered has at present perhaps no sufficient purpose, but it is interesting to see that the cephalic part of the axial lobe always receives fibres exclusively from the ventral peduncle so that the suggestion that it contains the homologues of the anterior cortical regions receives an important substantiation.

It has proven possible to trace the fibres from both dorsal and ventral peduncles into the cells.

In all cases except the superficial zone of horizontal or oblique cells and the large multipolar cells of the central lobe the apex of the cell directed *from the ventricle* passes directly into a strong fibre. The course of the fibres can also be followed with all desired distinctness. This fact has a very important bearing on the interpretation of cerebral structure in other groups. As I shall endeavor to show elsewhere, we have a similar arrangement in the amphibia. It is in fact the primitive arrangement in all cases.

This is perhaps the place to mention a small *nidulus radicis lateralis* consisting of a few cells of very large size situated on the radix at the point of exit from the pero. These cells are fully twice as large as those of the ganglionic layer of the pero.

II.—*Tracts from the hemispheres.*

1. *Tænia thalami.* In most brains examined there is a peculiar train of Deiters' granules which first appears on the lateral aspects of the præthalamus near the level of the præcommissura and not far from the hippocampus It can be traced with accompanying fibres to the mesal aspects of the peduncles, thence with the latter into the mid-thalamus, where the cluster speads out on the surface in front of the habena and the peduncular fibres sink into the deeper ventral portions between the optic tracts. This tract contains unmedullated (?) fibres and is probably the homologue of the tænia. The actual connection of this tract with the fibres from the habena has not been followed and there are a number of points in respect to this region which for the present must be left open. Other tracts from the hemispheres into the upper and middle parts of the midthalamus have thus far proven impossible to trace definitely to either terminus.

2. *Ventral peduncles.* As above stated, we have been so fortunate as to make out the actual cellular connection of the peduncular fibres with apex processes of the cerebrum. It was a gratifying surprise to find that the dorsal and ventral peduncles have a distinct origin in the hemispheres as well as a distinct course in the mesencephalon. Although we have carefully avoided attempting specific homologues for the several parts of the axial lobe yet the fact that its cephalic portion gives rise to the ventral peduncle and its caudal portion to the dorsal goes far toward substantiating our suggestion that in the axial lobe there are the representatives of the cortical centres of higher vertebrates and a certain similarity in general arrangement. Moreover, that part of the brain connected by the callosum proves to belong chiefly to the ventral system. After passing in company with the dorsal peduncles caudad of the chiasm the ventral portion describes a latero-ventral curvature. In those fishes in which the hypoaria are divaricated, as in the cat fishes, the ventral peduncle turns sharply laterad and is thus easily distinguished from the dorsal portion, even in horizontal section. In other cases the course is almost directly ventrad, and perpen-

dicular sections allow of the best differentiation. In either case the bundle collects into a circular tract which passes without branching through the cephalic division of the hypoaria and then divides into a vast number of small circular bundles. The arrangement is interesting and can best be understood from figures 1–4, Plate IV. Fig. 1 shows the passage of the bundle into the base of the hypoarium where the fibres diverge in arches much as the fingers might close about an apple, except that each finger is represented by a series of bundles in the meridianal plane passing toward the surface. In this region the fibres make connection with the peculiar bifurcate cells of the hypoaria. This takes place in the cortical part of the hypoarium and the fibres which arise from the other limb of the cells pass dorsad, enter the medullary portion, and effect combinations with several other systems. The nature of the combinations is well illustrated on Plate IX and will be discussed under the head of the hypoaria. Suffice at present to say that there is direct connection with the cerebellum and indirect connection with the dorsal tract. Immediately caudad of the margin of the hypoaria is the pons region with the commissura ansulata and decussatio tegmenti. There can therefore be no doubt that the hypoaria belong in the region of the pes pedunculi and the outer or cortical portion may be regarded as a cellular modification of the crusta while the medullary cellular region contains the homologue of the tegmentum with the nigra and ruber. The specific homologue of the ruber is apparently found in the nucleus rotundus, Fritsch.

3. *The dorsal peduncle.* The fibres which collect from the occipital and temporal lobes or, in general, from the caudal and caudo-lateral portions of the axial lobes form a stronger bundle than the ventral peduncle and pass with the latter into the thalamus; but instead of curving ventro-laterad after passing the chiasm they continue caudad until in the vicinity of the nidulus ruber and nidulus subthalamicus, into both of which they send a strong contingent by a sudden lateral flexture. Some of the fibres seem to continue into the ventro-lateral fascicle of the medulla and these may be derived from the ventral bundle, but of this it is at present impossible to be sure. In any case it is but a small

tract which crosses the ansulate commissure in the region of the exit of the oculomotor.

The main body of the bundle is broken up into numerous tortuous bundles which pass into and around the substance of the two niduli mentioned. The whole region is filled with cells of various sizes, especially the multipolar switch cells described especially under the account of the nidulus ruber and niger. From this subthalamic region a strong multiple tract passes ventro caudad into the medullary portion of the hypoaria (nidulus niger) where the fibres enter one of the processes of the enormous "switch cells" of that ganglion. A connection is thus formed with the fibres of the ventral peduncles in an indirect manner. This enormous development of an anastamosing system may be regarded as a partial compensation for the reduction of a similar system in the cerebrum. From the nidulus ruber and regions immediately adjacent fibres pass to the dorsal part of the medulla, but have not been followed in detail. A rather strong band passes from the dorso-cephalic portion toward the dorso median part of the thalamus. This tract is composed of non-medullated fibres with cellular accompaniments and must not be confused with the much more conspicuous tract of the commissura horizontalis which, after passing from its crossing caudad to the cephalo-ventral part of the nidulus, continues obliquely through it, emerging dorsad where it meets the tract of the cephalic peduncle of the cerebellum which comes into actual contact with but does not enter the nidulus, then both tracts pass dorso cephalad to their termini in the nidulus corticalis as elsewhere described. The strong tract from the base of the ruber was seen by Fritsch and regarded as the continuation of the dorsal part of the horizontalis tract and accordingly the whole was called columna fornicis. (Figs. 1, 2, Plate VI, will illustrate these points.)

5. *The "basal cerebral fasciculus."* This tract, which was described in Vol. I, p. 356, is certainly crossed, and the axial commissure of Edinger is accordingly a decussation. The fibres originate in the region of the mesaxial lobe and decussate caudad of the other anterior commissure bundles. They are very fine and remain near the median line and part at least of the bundle

can be followed into the infundibulum and constitutes the so-called fornix tract described below.

Fornix tract. Although warned of its apparent rashness, I must again call attention to the fact that a definite bundle on either side of the median line can be traced from just in front of the anterior commissure to the dorsal part of the tuber, where it dips ventrad into the immediate vicinity of the gray matter forming the mammillaria of this paper. The tract can be seen in almost its entire extent in longitudinal perpendicular sections. It seems hard to avoid the identification with the fornix columns.

III.—*The Præthalamus and Tuber cinereum.*

1. *The niduli* of the præthalamus have been previously mentioned and seem to belong to a single system.

The nidulus præopticus lies in the præthalamus cephalad of the optic chiasm and is a part of Meynert's ganglion opticum basale. It is composed of a mixture of cells of various sizes and forms. In longitudinal sections of the drum the dorsal part of this nidulus, where it adjoins the peduncles, contains very large deeply staining multipolar cells giving off large fibres. There are more numerous pale cells ventrad and adjoining the ventricle, while a few scattered cells of less than half the size, about as large as those of the fore part of the cerebrum, accompany them. Numerous small "Deiters' nuclei" also cluster in this region. The whole region is filled with blood vessels. In horizontal sections the principal cell cluster is seen to adjoin the ventricle and is crossed dorsally by the fornix tract to the tuber. In the ganoids the same nidulus occurs, but the cells are smaller and less distinct. In *Lucioperca* the nidulus lies in the narrow isthmus between the strong optic tracts, and the two portions are very obvious. The dorsal part, consisting of large multipolar cells, reaches nearly to the habenulæ. The two portions are well shown on Plate VIII, Fig. 4, *a* and *c*, and cells from the dorsal portion are figured in Figs. 5 and 5*a* of the same plate. (See also Fig. 1, Plate V; Plate VII, Fig. 7*a*. Also vol. I, Fig. 5, Plate XX.)

The *nidulus postopticus* is a clustre of large multipolar cells very like those of the dorsal part of the præopticus and probably morphologically equivalent to a separated portion of the latter. It passes in some cases upon the cephalic aspect of the tuber forming two dorso-lateral cell clusters. In *Lucioperca* these cells are enormously developed. The function and nature of these highly specialized cells is unknown; they remind one of the cells described by Fritsch in the dorsal part of the medulla of *Lophius*, which are often penetrated by blood vessels and are the sources of large fibres passing out with the fifth nerve. How such a perforation could take place is illustrated by Fig. 5, Plate VII. These cells also resemble those of the mesencephalic root of the fifth and the cells of origin of Mauthner's fibres.

In transverse sections of the eel the large cells of the præopticus nidulus which lie between the optic tracts give off large, deeply stained, unmedullated fibres which pursue a lateral course with those of the ependyma toward the lateral walls, i. e. optic tract region.

The ependyma fibres apparently arch cephalad about the optic tracts and find their ectal terminus on the caudo-lateral aspect of the hemispheres, a course which is due to the fact that the constricting effect of the optic chiasm has separated and distorted the relations between the ectal and ental walls of the region in question.

2. *Tuber cinerum and tract to ventral commissure.* A horizontal section of the infundibulum at the position indicated in Fig. 2, Plate IV, shows that the cephalo-ventral wall of the infundibulum consists simply of a thin layer of epithelium upon which the fibres of the hypophysis lie on their way to their definitive locus on the lateral aspects. On the caudal aspect lies the transection of the caudal stalk of the hypophysis from the saccate portion. The caudo-lateral aspects are occupied with the recessi laterales infundibuli, of which more anon. The regions adjoining the ventricles are well filled with cells and supplied with capillaries. The cells are of the small fusiform sort and send their processes cephalad for the most part. They are especially numerous about the recessus infundibuli.

In this region also it is possible to observe the origin of clusters of nerve fibres from the cells mentioned and to follow the tracts to their union with the ventral commissure. These disperse bundles collect cephalo-laterad and form a strong bundle (*tractus tuberi ad com. ventralis.*) These fibres *do not decussate* but fuse with those of the ventral commissure and, going with it, seem to pass into the lateral aspects of the colliculi.

The resemblance of this tuber bundle to what Dr. Edinger has described as the "mantle bundle," arising in the cerebrum of Selachii, is so great that repeated attempts have been made to find a similar relation in Teleosts, but thus far without success. Dr. Edinger writes me that he thinks the structures distinct. The close relation of this tract with the dorsal peduncles at one point makes it possible to pass from one to the other if great care is not exercised.

3. *The mammillare, post-cinerea, and conus præcommissuralis.* It has been already mentioned that there are definite expansions of the infundibulum upon the caudal aspects of the tuber. Although the protuberances produced thereby are often covered by the saccus and hypoaria we have seen no brain in which they were absent. The cells adjacent are fusiform and more or less concentrically arranged. The peduncles of the saccus pass between them and fibres arise in the neighborhood dorsad and can be traced cephalad to the region of the anterior commissure (*fornix tracts*, above.) Immediately cephalad arise the fibres which pass to the ventral commissure, while another tract passes toward the habena. When we take into account the position and fibre-connections and constancy of occurrence, it seems impossible to avoid comparing these bodies with the mammillaria. The attempt which has been repeatedly made to homologize the hypoaria with the mammillaries is obviously utterly futile, for not only are they situated in an entirely different region, but the fibre connections forbid any such reference. A tract from the mammillaries to the cerebellum and the reception of the ventral pyramids by those bodies would be unreconcilable. From a level somewhat dorsad the ventricles of the hypoaria diverge latero-cephalad and then suddenly ventrad, dividing into two cornua. Morphologically these ventricles are rather ventrolateral pouches of the aqueduct than extensions of the third ventricle, as they seem to be.

Somewhat dorsad of Fig. 2, Plate IV, there appear two protuberances of the dorso-caudal aspect of the tuber which contain only irregularly arranged spherical granules. These may be followed dorsad until they acquire a peculiar corrugated structure and disappear at the level where the conus præcomissuralis becomes most prominent. These may conveniently be termed the *post-cinerea* and seem to have no homologues in other groups. At the higher levels they fuse wlth the nidulus niger, but never seem to contain other elements than the small "Deiters' corpuscles" imbedded in a dense stroma which stains deeply and homogeneously. The conus præcommissuralis of Fritsch lies between these masses and cephalad of the post-perforata (substantia perforata posterior) which, as mentioned by C. Judson Herrick above,[1] is a constant point characterized by the presence of a large vessel. Fritsch homologized this with the interpeduncular body, but I am obliged to agree with Mayser, that it does not receive the fibres of Meynert's bundle which pass on to enter the post commissuralis. The latter is therefore the specific homologue of the interpedunculare The present structure is devoid of ganglion cells and consists of a meshwork of fibres and Deiters' corpuscles. It may be regarded as a nutritive region like that of the præperforata. It might be supposed that the post-cinera were also in some way associated in the nutritive processes.

4. *The infundibular region and hypophysis.* A great deal of unnecessary trouble has arisen in the interpretation of structures which have unmistakable homologies in all vertebrate classes. The tuber cinereum is well-developed and completely distinct from the hypoaria and stands in perfectly normal relation to the corpora albicantia (mammillaria) and to the hypophysis. The latter is constructed on a plan similar to that in mammals, except that two portions which have a distinct origin are in the latter group partly combined, while in fishes they remain distinct.

In the drum (*Haploidonotus*) our series of perpendicular sections gives a complete idea of the connections of the axial portion, or saccus vasculosus. The relations with the cinereum are two-fold. The dorsal surface of the saccus lies closely appressed to the caudo-ventral aspect of the cinereum. From the point of structural union at the extreme caudo-ventral point there passes into the saccus a rather strong stalk of fine fibres

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[1] C. JUDSON HERRICK. Contributions to the Morphology of the Brain of Bony Fishes. I.—Siluridæ. Vol I, p. 223.

which have the aspect of small non-medullated nerve fibres. These fibres occur in the form of a cylinder composed of separate strands about a cavity. This cavity communicates by means of a narrow horizontal tube in the substance of the cinereum with the ventriculus infundibulus at the point where the latter closely adjoins the anterior part of the hypophysis proper. Tracing the peduncle of the saccate part of the hypophysis dorsad its fibres are followed to a point where they are associated with similar fibres from the mammillary. Of the course of the fibres, however, nothing sufficiently definite could be discovered. They doubtless turn ectad. The ventral course of the peduncular fibres is as in Didelphys. They pass ventrad and diverge laterad, forming two irregular series on either side of a median cleft. Beneath this level the sac becomes a complicated maze of convolutions due to the folding of the walls and the filling of the interspaces with a dense reticulum of blood vessels. The number of vessels crowded into these narrow lamellæ is wonderful. The fibres lie in separate bundles within the convolutions surrounded by blood capillaries.

The walls of the convolutions are composed of a single layered epithelium with large spherical nuclei.

The fibres constituting the bundles above mentioned have scarcely the aspect of connective tissue but stain densely and assume a granular appearance. They are devoid of nuclei except small granules which sometimes appear to enter a sheath about the bundles but this seems to have no general significance. In properly orientated sections we at last succeeded in demonstrating that these fibres spring from the long apical process of the cells of the epithelium, which therefore is exactly like the similar layer of ependyma cells throughout the nervous system. It should be observed that the process is turned from the ventricular surface and the fibre passes among the blood vessels which lie morphologically between the ependyma and the ectal surface. The ectal surface corresponding to this epithelium lies somewhere above in the thalamus and the blood vessels lie morphologically between the two. The relation is difficult to explain but if one will imagine a portion of the wall of the thalamus consisting of an epithelium with fibres radiating to the surface, while a number of blood vessels lie between the two, and then imagine an expansion due to a proliferation of the ependyma and great increase of the mass of blood-vessels, while the ectal attachment of the (now greatly elongated) fibres is retained, the suggested origin of the structure will be understood.

The connection of the fibres with fusiform cells of the membrane, at any rate, is perfectly clear, and the obvious interpretation of the structure is that it is an outward development of plexus similar to those which fill the ventricles and may have a similar function in the elaboration of a nutrient fluid or the like.

In a series taken in various directions through the brain of very young and later stages of *Amiurus* we have a clear illustration of the mode of origin of the two related structures.

It should be remembered that in the adult catfish the saccus reaches an extreme development, being, as stated by C. Judson Herrick, a mere epithelial sac. In the very young the two bodies spring from the iter infundibuli at the same point, a slender canal passing some distance into the anterior (hypophysis) portion which receives abundant connective fibres from the tuber. These fibres are apparently related to the epithelium as above described. From this dorsal expansion there is also derived a sac which expands caudad into a small chamber whose walls are convoluted. In this stage it is easy to see that the convolutions are due to the pressure of blood vessels. The cephalic portion is closely associated with the cephalo-ventral aspect of the saccus, while the dorso-caudal portion of the latter is appressed upon the mammillary bodies.

In a somewhat later stage the sac has enormously enlarged and the enlarged portion is devoid of convolutions but retains the essential characteristics. The glandular portion is also greatly enlarged and its strong peduncle of fibres can be traced along the ventro-cephalic aspect of the tuber and dorsad into the region of the ventral peduncular bundles, accompanied by those of the saccate portion. The glandular portion consists of a closely packed mass of follicles with blood vessels within, the saccate part is a single layered epithelium giving off connective fibres ectad and covered by a reticulum of capillaries ectad of these fibres. It is interesting to observe that the axial part of the glandular part, i. e. that portion derived from the brain and connected with the saccus has the same structure as the latter. The epithelium lining the prolongation of the infundibular ventricle gives off fibres which lie adjacent to the epithelium and ectad of it.

Now returning to the drum, we observe in horizontal sections that the hypophysis proper is composed of two distinct portions, an axial portion derived from the brain and in essentials of structure much like the saccus which is to be regarded as a separated portion of it, and an outer zone which is quite distinct and has exactly the structure found in the opossum. There seem to be some nerve cells in the axial portion which doubtless arise as elsewhere in the central system as outgrowths of the epithelium. This part differs from the saccus only in its denser epithelium and and more complete convolution. The connection of the fibres with epithelium cells is beyond question. The relation of fibres and blood vessels is identical in the compared organs. It seems quite beyond question that these two portions are homologues of the axial portion of the hypophysis of Didelphys while the outer or mantle portion is derived from the pharynx.

In *Carpiodes* the hypophysis is well developed and the saccus quite small, the development of the two seems, as might be expected, to sustain an inverse relation. The connection between the very small ventricle of the hypophysis and the convoluted cavity of the saccus is direct, though a small protrusion of the tuber separates them. One can trace direct connection between the ventricle of the peduncle of the hypophsis and some of the main diverticula. The medullary part of the hypophysis is very large and contains two lateral portions of a denser character which may represent the outer layer of higher animals although there is in addition a small envelope of the usual sort. The epithelium cells can be traced into definite connection with the fibres of the peduncle which also bear scattered intermediate nuclei of spindle form (inoblasts). It does not seem probable that there are many nerve fibers among the tracts, though their presence is not excluded. The epithelium of the saccus is strongly ciliated. The stalk of the hypophysis forms a sort of irregular decussation or confusion of fibres after which two lateral bundles collect and pass cephalo-dorsad to the latero-cephalic regions of the tuber. A cluster of distinct polyhedral cells lies laterad of these tracts near the surface in all fishes examined.

In *Carpiodes* the lateral recesses of the tuber, forming the mammillaria in a restricted sense, are large and double and the bodies lie cephalad of the spur-like caudal lobe of the hypoaria. Dorsad of the decussatio hypophysis a lateral spur of the ventriclus infundibuli forms a projection into the latter from the region of which, as well as from the caudo-lateral regions of the tuber, the fibres of the tract from the tuber to the ventral commissure arise.

In larvæ of Salamander just removed from the uterus the hypophysis, which is closely attached to the greatly prolonged infundibulum, consists of a medio-caudal portion already distinctly follicular, and a bifid cephalic portion which is extended laterally some distance. Only the first mentioned median portion is directly connected with the infundibulum, which latter consists is this region of a single layer of the epithelium. In the adult the two portions are not easily distinguished in our sections. The majority of the mass being composed of follicular tubules and blood vessels.

Here we have the same distinctions and there is also a more or less evident saccate modification of the infundibulum in the region of the attachment of the hypophysis which corresponds probably with the saccate lobe of the latter in fishes.

In the the case of *Menopoma* there is a well defined saccus vasculosus lying caudo-dorsad of the hypophysis and here the relations seem entirely similar to those above described in fishes. The whole lateral surface of the infundibulum is covered with a dense net work of capillaries and at the point of union with the saccus the latter force their way inward, not entering the ventricle but pushing the epithelium inward as the whole wall spreads outward. The result is a plexiform sac as above described. The connection with the anterior part of the hypophysis is more direct than in fishes.

IV.—*The interoptic commissures*

The various bundles of transverse fibres immediately adjacent to the chiasm always prove difficult to distinguish. In higher vertebrates these commissures have been so variously described and the same commissure has so often received different names that, after long effort to unravel the maze, it has been decided to describe the commissures as they exist in the fish, under such terms as seem least ambiguous, without attempting to reconcile therewith the discordant statements of Forel, Ganser, Meynert, Edinger and others. Mayser has given the most accurate account of these structures from which, however, we are obliged to differ in several particulars. It should be observed that teleosts afford the simplest connections and here, if anywhere, the problems are to be solved. Moreover the great variation of form in fish brains is of much assistance, because the same tracts are thus brought into very different topographical relations while, of course, the real connections are constant.

1. *The commissura ventralis*—one portion of the inferior commissure, Gudden's commissure (?). It is the most ventral of the system and in the drum is entirely distinct from the optic nerves. It is in fact separated by a large part of the geniculatum at the base. Fig. 5, Plate IV, gives an especially clear idea of its position. Compare also Plate VI, Fig 1. This has been considered a decussation and for a long time we entertained this opinion. Fig. 4, Plate IV, seems to substantiate it, but a very careful study shows that there is no decussation. The fibres which arise, as elsewhere described, in the tuber near the mammillare, collect on the cephalo-lateral aspects of the tuber and associate themselves with the fibres of the commissura ventralis of that side, passing with them into and through the geniculum to the lateral aspects of the colliculus and brachium caudale.

2. *The commissura transversa* (Halleri) is the most closely associated with the chiasm and was regarded by Professor Fritsch as a separate arch from the chiasm.[1] Obviously Fritsch has combined in his account the two systems, transversa and ventralis. We have been unable to find any connection between the optic fibres and those of this commissure. The probability of mistake is rendered less likely by the difference in calibre of the fibres.

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[1] "*Die Com. transversa* . . . gilt als ein Convolut zum *Tractus opticus* hehöriger, abgezweigter, zum Theil in dass *Tuber cinereum* einschliesender Bündel . . . wenn ich auch nicht dafür eintreten möchte, dass ihre Fasern lediglich *Opticus* Fassern sind." L. c., p. 57.

Passing adjacent to the optic tract it accompanies the anterior division to the region near the entrance of the latter into the tectum, where it is interrupted in a cell mass from which springs the cephalic brachium of the tectum.

3. *The commissura minor* forms the most dorsal of the systems. Its relations to the other commissures will be obvious on the comparison of Fig. 1, Plate VI, with Fig. 6, Plate IV. It is one of the most perfect commissures of the brain and its sharp dorsal curvature after crossing is characteristic. It lies far removed from all other tracts and is quite unambiguous. Its fibres pass to the interval between the two branches of the optic tract, perhaps to the same region as the com. transversa. It appears not to have been described unless it was included by Mayser as a dorsal portion of the transversa.

4. *The commissura horizontalis* (Fritsch) is the most distinct of these systems and is mentioned in connection with several other organs. Its strong band of large fibres forms a distinct loop across the median line and by a gentle reverse curve passes to the nidulus ruber, passing through it in a curved course, emerges and, with the cephalic peduncle of the cerebellum, enters the nidulus corticals adjacent to the habena. It was adequately described by Mayser, who, however, could not determine its relations to the posterior commissure. Its crossing and a part of its upper course is shown in Fig. 5, Plate IV. In Fig. 6, it occupies the centre of the ruber. Its union with the anterior peduncle is seen in Fig. 2, Plate V. Fig. 2, Plate VI, shows a greater part of its course from the ruber to the corticalis.

It should be noticed that this commissure is curiously sinuous in its course, first turning dorso-caudad, then is depressed by the crossing of the dorsal peduncles so that in Fig. 5, Plate IV, it appears twice.

5. Immediately ventrad of the horizontal commissure a small but very distinct bundle of very small fibres forms a commissure (*com. superior tuberi*), which pursues a curiously tortuous course; passing caudo-ventrad, then plunging ventrad, lying mesad of the ventral peduncles (Figs. 3, 4, Plate IV); thence it passes caudad of the latter to the lateral aspect of the cephalic cornu of the hypoarium, where it again turns dorsad and caudad and loses an independent existence by mingling with the fibres

near (*a*) Fig. 3, Plate IV, not much ventrad of the commissural portion. It may be presumed that its fibres ultimately reach the nidulus ruber (rotundus) and it would then simply signify a curious deviation from the com. horizontalis with the fibres of which these correspond. There are about 30 very large and well-medullated fibres.

In the study of the commissures the composition diagrams formed by drawing the superposed outlines of two transverse sections separated by a small interval and filling in the details on one side from one section, on the other side from the other, prove very useful. Thus Fig. 1, Plate XII, has on the left side details from a section immediately caudad of the chiasm, while the right side is some distance caudad at the junction of the hypophysis. The outlines of the second section are distinguished by shading. On the left side a portion of the cuneus and hippocampal lobe of the hemisphere remain, on the right, the temporal lobe has become distinct and the mesaxial lobe has nearly disappeared. On the left the dorsal peduncle is just entering the thalamus. The commissura transversa is cut in the middle and a small portion of the inferior commissure is seen. The tuber still retains the fibres which unite with the latter (*Tr. tub. ad Com. v.*) adjacent to which is the nidulus tuberis dorsalis. On the right side the two peduncles are distinct and separated by a small cell cluster, the transverse commissure is seen adjacent to the optic tracts ascending with the latter, but perfectly distinguishable by reason of its smaller fibres. The geniculatum is also well-developed in this region and the tract. tuber. ad com. ventr. is passing from the tuber to join the commissura ventralis on the ventromesal aspect of the geniculatum.

In Fig. 2, we have two sections from regions still farther caudad, similarly composed. On the left side the commissura horizontalis is in section and immediately ventrad lies the dorsal tuber commissure, both of which turn caudad, the former to the nidulus ruber. The commissura minor, which in Fig. 1 was in section, is now on its way dorsad and on the right side has nearly reached its specific terminus in the interval between the dorsal and ventral optic tracts. On the right side the vent. peduncle is passing into the hypoarium and the mammillare contains a closed chamber, recessus infundibuli posterior.

The commissural systems of the chiasm region are crowded apart in *Dorosoma* by the enormous development of the optic nerves and chiasm, so that they are very completely distinguished. Fig. 8, Plate XXI, Vol. I, gives a good idea of the relations at the point where the ventral and dorsal portions of the optic tracts are separating. In the narrow isthmus between the optic tracts the peduncular tracts and a part of the commissural tracts, are closely crowded. At *e*—broken in the plate, but next above *vent.* III *v.*—is the point of crossing of commissura horizontalis. Above it, at *d*, are tracts from the commissura minor which a few sections caudad passes sharply laterad to the cell layer above the ventral optic brachium, as in all other cases. It is followed cephalad a long distance and decussates above the commissura transversa in the limited area behind the chiasm. There is some suggestion of a decussation, however, and the question is perhaps not to be decided without a more complete series of this species. On either side, adjacent to the ventral optic brachia, is the obliquely cut portion of the commissura transversa, between which and *d* is the ventral peduncle bundle, while dorsad of it, at *b*, is the dorsal peduncle which becomes distinct farther caudad. On the right side of the figure, above the nidulus *f*, is the tuber tract to the ventral commissure, which crosses in a section cephalad. A short distance caudad the ventral peduncle turns directly ventrad so that its entire course can be traced from the thalamus to the ventro-lateral region of the tuber near the hypoaria, into which the fibres enter.

According to Edinger, the commissura transversa is probably a decussation. "Sie durchzieht fast die ganze Breite des infundibulums, und es wenden sich nahe der lateralen Ausenfläche ihre Fasern rückwärts und aufwärts um sich im hinteren Bereich des Mittlehirnes nahe dem Dache dann der weiteren Beobachtung zu entziehen." He compares it to Meynert's commissure of mammals.

It appears that no homologue of the commissura horizontalis has been found in Selachii by Edinger.

V.—*The dorsal region of the thalamus.*

1. Respecting *the epiphysis* and *dorsal sac* there is nothing additional to mention. A comparison of Figures 7 and 9, of Plate VII, with the transverse section, Fig. 5, Plate VIII, shows that the connection of the epiphysis with the third ventricle is direct and that the dorsal sac is greatly restricted basally.

2. The *habena* is obviously double and contains small fusiform cells which give off processes which pass into the tænia cephalad and into Meynert's bundle ventro-caudad. The relations are precisely as in Amphibia and if the suggestion of Professor Fritsch be correct, that the habena of fishes does not give rise to nerve fibres and that Meynert's bundle is not nervous, then the like applies to the same structures in Amphibia and Reptilia. Of the homology of the organs with those of higher vertebrates bearing the same names, there can not exist the slightest doubt. The microscopic structure of the habena is shown in Fig. 7, Plate VIII. The nidulus lying below it, in the path of Meynert's bundle, seems to give rise to some of the fibres of the latter and has been called in reptilia Meynert's nidulus. The cells are small and resemble those of the habena, Fig. 6, Plate VIII. The longitudinal sections of young specimens of *Belone*, Figs. 1, 2, Plate VIII, are designed to show the relation of these niduli to the central gray.

3. *Meynert's bundle* may be readily followed from its origin in the habena almost in a direct line to the interpeduncular nidulus, which is double and contains few cells. On the way a number of medullated fibres are incidentally associated with it, but are not a part of the bundle proper.

4. In the region adjacent to the habena and dorso-laterad of the dorsal commissure, a vast number of important tracts and organs are crowded into the narrow space left between the optic tracts. The superior commissure, in which there is a faint indication of the development of a double system (superior and habena commissures) as described by the writer in reptiles and subsequently, we believe, by Edinger, is well-separated from the posterior commissure and optic tracts. In this space is a multiple nidulus of cells of varying size, which may retain the unfortunate name given it by Fritsch, n. corticalis. From the lateral portion with its large cells, arises the commissura horizon-

talis tract composed of large fibres which, passing caudo-mesad and then ventrad, unites with the tract next to be mentioned until the level of the nidulus ruber is reached, when it passes into and through that nidulus, as already described. The second tract arises in the mesal denser part of the nidulus corticalis and consists of finer fibres, which can be distinguished from those of the horizontalis tract even when the two are intimately associated. The point of origin is considerably dorsad of the posterior commissure. Describing a gentle arch ventrad, the tract passes again dorsad into the anterior peduncle of the cerebellum. It is therefore a direct cerebeller thalamus bundle. In mammals a similar bundle arises in the thalamus, comes likewise into close relations with the red nidulus, and makes up the principal part of the anterior peduncles of the cerebellum, but it is a *crossed* bundle. The apparent incompatibility is reconciled when we discover that this tract crosses to the other side within the cerebellum of fishes.

Plate VI, Fig. 1, gives the dorsal course of the tract and indicates by dotted lines it complete extent, while in Fig. 2, the cephalic portion is in section. The region ventrad of the nidulus corticalis contains the origin of Meynert's bundle from the caudal margin of the habenæ and the origin of the dorsal and cephalic part of the posterior commissure fibres in the baso-lateral part of the region of the corticalis. It seems probable that the dorsal commissure is a decussation of the posterior longitudinal fascicle, whose fibres are the only ones entering from the caudo-ventral direction. The whole mass has the appearance of a decussation, but at this writing evidence is not completely satisfactory.

The *posterior longitudinal fasciculus*, after pursuing a course parallel to the ventricle, until it reaches the vicinity of the third nidulus, spreads out into a loose mesh-work passing among a series of very large cells, from which the largest sized fibres of the fasciculus spring. The fibres can be traced with ease from the process of the cells into the tract. At this level fibres from the tectum enter, and seem to communicate with the third and fourth niduli, while others, after decussating, continue toward the base and enter the middle peduncle of the cerebellum. Fibres from ventral levels may associate themselves in this bundle, but there is no evidence of it. The region of this Mauthner's nidulus, where the fibres disperse, is also one rich in blood-vessels.

VI.—*Optic nerves and brachia.*

The course of the two divisions of the optic nerves is perfectly simple and not difficult to follow. The two roots pass together for some distance dorso-caudad, until they meet the protuberance of the tectum. Theoretically they would spread out over the entire ectal surface of the latter, but the form of the tectum is rather lunate than hemispherical, so the fibres destined to the caudal part separate and pass in a horizontal plane caudad to the posterior cornu, while the cephalic division turns dorsad to the anterior cornu of the crescent. In the space left by the two divisions the ventral commissure passes toward the terminus in the corpora posteria, while the transverse commissure follows the cephalic branch toward the level of the habena. The caudal optic tract spreads out within the outer or neuroglia layer, radiating dorso-cephalad to fill the space not filled by the fibres from the cephalic tract with dorso-caudad radiations. The nature of the terminations is discussed further on, but the morphological relations are absolutely simple. Perhaps they could be illustrated best by the two hands, the arms of which are placed parallel and represent the two divisions, while the fingers of the one arch about one side of a sphere and those of the other arch in the opposite direction, so that the finger-tips meet above. The complications encountered in the study of the tectum grow out of the commingling of other fibres. Yet even here, when once understood, the arrangement seems very simple. The most superficial of these systems is the transverse system, or sylvian commissure (commissure of the optic lobes) which is a pure commissure or decussation of the tectum. The origin of the fibres is in the reticular zone in the outer or neuroglia layer, whence they pass more or less directly across to the other side, their course being greatly modified by the development of the torus, divarication of the tectum by the volvula, etc., in the several cases. In general these fibres converge cephalad. In the drum, for example, where the roof of the mesencephalon has been rotated through an angle of nearly 90°, the fibres are forced to make a long detour. In entering the torus they dip through all the other strata of the tectum. See Figs. 1 and 4, Plate VI, Figs. 6 and 9, Plate VII, and Fig. 8, Plate VIII for examples. A considerable part of the fibres which enter the torus longus are not nerve fibres, but arise from the modified epithelium of that body and pass to the ectal surface of the tectum. Such *gelatinous tracts* are to be regarded as mere persistent walls of the original single layer epithelium and add proof, if it were necessary, that the torus is but a part of the tectum. The greater number of such fibres form a support for the mass of optic fibres where the brachium cephale enters the tectum (Plate VII, Fig. 9.)

A third system belongs to the thalamus and its commissural tracts. It is chiefly limited to the cephalo-dorsal part of the tectum and its fibres collect above the granular layer into small circular bundles which in transverse section are transversely cut and in longitudinal section lie in the plane of section. These bundles collect ventro mesad of the cephalic optic tract fibres and pass with them to near the level of the habena, thus constituting the origin of the cephalic brachium. They are diffused in the same nidulus from which the transverse commissure fibres arise. It also appears that the commissura ventralis sustains the same relation to the caudal optic tract, except that the commissural fibres are more closely associated with those of the optic tract than in the previous case. That part of the ventral commissure tract which is derived from the cinereum, however, passes into the torus semicircularis (colliculus).

If the above relations are correctly made out, tho essential structure is simple indeed. There is morphologically a single ventral commissural system related to the optic system and to the brachia. The same cause which has operated to divaricate the two portions of the optic tract may have separated the ventral system. There is apparently an interruption and cellular interpolation in both divisions.

The caudal system remains to be considered. Collectively these fibres constitute a strong bundle passing through the colliculus from their origin in the ganglion layer of the tectum ectad of the granular zone. These fibres enter the colliculus in concentric order and there divide into several sheathing concentric zones of fibres parallel to the latero-basal aspects of the colliculi. There then arises a distinction between a larger, ectal, lemniscus portion and a smaller, ental portion which seems to pass, after decussating, into the cerebellar peduncles. The lemniscus portion passes to the region of the pons and gives off other fibres to the cerebellar decussation, while the remainder accumulates on the latero-ventral aspects of the medulla.

Undoubtedly something more than a brief statement is necessary to be convincing of the correctness of statements so at variance with the descriptions of earlier writers. It will not be possible at present to publish the numerous figures necessary to elucidate these points so that a more detailed discussion is held in reserve, in the hope of making wider comparisons. The statement of Fritsch that the caudal root of the optic tract rises in the colliculus has not been verified. Nothing is easier in some of our series from large-eyed species, where the horizontal section is inclined somewhat ventro-cephalad, than to follow fibres, almost in a single section, from the root to the caudal portion of the tectum. It is perfectly certain that no considerable portion of these optic nerve fibres enter the stratum zonale of the colliculus. On the other hand the fibres of the ventral commissure can be followed to the stratum zonale, though, as above said, those of the commissure proper seem to go on into the tectum. Our study supports Bellonci's statement that there is no connection of the optic nerve fibres with the geniculatum, though we think the posterior brachia, i. e. the descending fibres from the tectum related to the ventral commissure, are interrupted in what may be a homologue of the geniculatum internum.

In a series of very thin transverse sections of *Lucioperca*, in which species the commissures are very much displaced in a longitudinal direction, we followed the ventralis very carfully, and feel sure that there is no passage of the larger optic fibres toward the colliculus. There seems also to be a decussation of a branch of the transverse commissure in this species. In that case the homology between the ventral and transverse commissures would be complete.

VII.—*The tectum opticum* is rendered difficult chiefly by the fact that the fibres pass through it from the numerous tracts in oblique directions and are rarely parallel so the spherical surface

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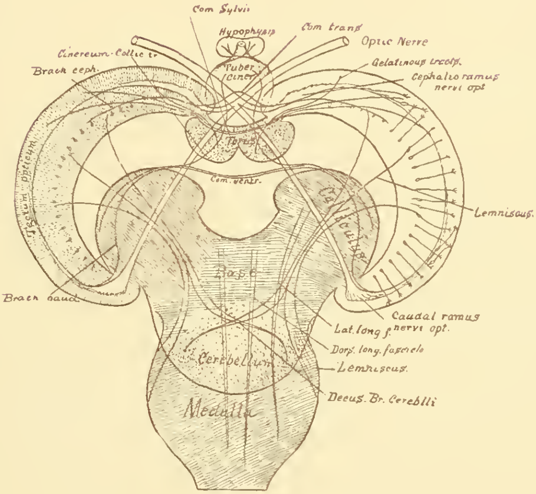

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or the planes of reference. The fibre tracts to be kept distinct are, 1. the optic fibres entering from the cephalo-mesal and caudo-lateral aspects respectively. These tracts are part of the same continuous sweep of fibres from the optic nerve, which have been separated by the architectural necessities of the brain, their internal course is morphologically identical. 2. The fibres of the cephalic and caudal brachia which, after affecting cellular connections at their exit from the tectum (?) connect with a double commissural system (transverse and ventral commissures) as above described. 3. The radiation to the lemniscus derived from the ventral ganglionic series of the tectum and passing to the lateral aspects of the medulla. 4. Associated with the latter the fibres of the middle peduncles of fhe cerebellum (decussatio tegmenti) and probably also fibres to the III, IV, and perhaps the VI nerve niduli. There may also be among them commissural fibres. 5. The sylvian commissure system whose fibres pass in a more or less complicated course from one side to the other, originating in the ectal reticulum of either side. 6. A system of fibres belonging to the category of gelatinous tracts, i. e. connective fibres springing from the epithelium of the ventricular portion of the torus and passing to the ectal surface of the tectum. This relation is especially well shown in Fig. 9, Plate VII, and Fig. 8, Plate VIII.

The connective framework of the tectum is constructed on the same plan as that of the rest of the brain and consists of a continuous epithelium with the base of each cell upon the ventricle and its summit at the periphery. The integrity of the series is greatly disturbed by the development of neuroblasts and their migration and the invasion of fibre tracts, as well as by the great changes in position suffered as a consequence of the development of the cerebellum and volvula. The primitive simplicity is retained more perfectly in Amphibia (*Menopoma*, etc.) Fig. 12, Plate X. To all appearances, the nucleus of the epithelium cell divides without causing division of the cell, yet this is not certain. After passing the inner ganglion layer the walls collapse and form a thread which may enclose one or more nuclei and terminate at the periphery in a cell. Figs. 1, 2, Plate IX. These are conspicuous in the young, but practically shrivel up with age. Between these cylindrical connective cells the neuroglia stroma, nerve cells and fibres develop. The cells develop from the neuroblasts of the ventricular region and accumulate between the connective cells up to the level of the first fibre belt, forming a basal cellular zone. The upper portion becomes functional and some cells migrate towards the periphery. By the gradual thickening of the tectum, the ganglionic layer is separated from the ventricular surface by an interval, 1, Fig. 1, Plate VII. The relation between the connective and nerve cells is well shown in Fig. 2, of the same plate. It seems to me that only the outer portion of the dense zone of nerve cells is functional and it is only with these that a fibrous connection has been observed, Fig. 3, Plate IX. The first layer of the tectum, beginning from tbe ventricle, therefore, consists of columnar epithelium cells whose protoplasm in the adult is more or less shrunken and whose nucleus may still remain distinct or may become imbedded in a thin layer of protoplasm adjoining the walls. The walls may collapse beneath the ganglion layer and there is frequently an intricate folding which produces a peculiar appearance in section, but Fusari has completely misinterpreted this appearance in Plate III of his work.[1] The appearance of a brush-like radiation of fine processes is illusory and in perfectly prepared specimens, not too much dragged in cutting, the walls of the cylindrical epithelium cells can still be followed. Above this level the whole tectum becomes charged with a dense mass of glatinous matter, giving it a homogeneous appearance. The (generally collapsed) walls of the connective cells pass directly toward the periphery and in some cases enclose nuclei with surrounding protoplasm. Whether these nuclei have simply retreated from the ventricular surface, or whether a single epithelium cell may have more than one nucleus, is uncertain, but at the peripheral terminus there is always a small fusiform cell-like body, as indicated in Figs. 1, 2, Plate IX. These were apparently figured by Fusari, as terminal expansions of ganglion-cell fibres in the plate above referred to.

It is only in well-preserved material that the distinction between the nuclei of the ventricular epithelium and the internal

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[1] Atti de Lincei Mem. cl. sc. fis. ecc Ser. 4, Vol. IV. Intorna alla fina anatomia dell' Encefalo dei Teleostei.

ganglion layer is obvious, but Fig. 1, Plate VII, and Figs. 1, 2, Plate IX, sufficiently differentiate them. A comparison with Amphibia shows that the same arrangement prevails there also. Thus Plate X, Figs. 9, 12, indicates the complete dlstinctness of the epithelium from the ganglion layer. Each ganglion cell has its peripheral process, which passes into the ectal layer of the tectum and there divides dichotomously, mingling with the optic fibres to form a fine reticulum. This zone is perforated at intervals by the lemniscus and decussating cerebellar tracts, whose fibres collect ectad. In many cases actual communication between fibre and cell could be seen, as in Figs. 1, 3, Plate IX. But there is also a partial commingling of fibres of the next layer at some levels. 4, in Fig. 1. Plate VII, is the zone of anterior brachial fibres. These enter with the anterior division of the optic tract and pass caudad immediately ectad of the lemniscus fibre zone, gradually disappearing caudad. These two tracts are approximately at right angles.

The fifth layer (5, Fig. 1, Plate VII,) is a dense band filled with a homogeneous gelatinous substance, through which pass the fibres from the apical processes of the ental ganglion layer. It also contains sporadic cells of that layer as well as possibly those forming the termini of the anterior brachium fibres; 6 and 7 cannot be topographically distinguished with precision; 6 is chiefly composed of transverse (sylvian commissure) fibres, while 7 is the layer of optic fibres passing more or less obliquely caudad. Within these two layers is contained the ectal layer of ganglion cells of large size and with elongate processes. The apex process terminates in a strong fibre which divides dichotomously and gives off its ultimate branches to the reticulum. Careful study with high high powers showed that these fibrils actually unite with or come into contact with the reticulum. The appearance of free termination, seen in Golgi preparations, seems to be unconvincing, especially in view of the imperfect conservation implied by that proceedure. The basal processes of these cell turns cephalad and seem to enter the optic tract, as seen in Figs. 1, 2, Plate IX, which are derived from very young fry of *Trutta*. These cells are still horizontal, but we believe that they gradually assume a radial position as a function of the thickening of the tectum.

In sections of the bass it has proven possible to trace the connection between the cells of the ectal ganglionic zone and ventral part of the optic fibre layer satisfactorily, while in most cases it is only possible to determine that the ventral process, which is very strong, suddenly turns out of the plane of the section. In those cases the fibres of the optic tract also fall out of the plane.

The connections of the other fibre tracts must be left for future study.

In Amphibia we should naturally expect to find the structure of the tectum most simply developed. A glance at the figures on Plate X will show that we have not been deceived. Fig. 12 is a section through the ental portion of the tectum as seen with a one-twelfth oil immersion lense, drawn with the camera to a scale. Some of the cells are drawn in from adjacent portions of the field, i. e. the section has been somewhat crowded, otherwise it is accurate. The nuclei of the epithelium or ependyma are large and more or less quadrangular, staining more deeply than the nerve cells above. In nearly all of the latter there may be demonstrated a long process from the sparingly developed protoplasm extending peripherad and dividing into a number of fine branches. The horizontal cells in the tract near the middle of the tectum have been found in only a few cases and seem to be cells like those beneath, which have been drawn out of their normal position by the growth of the tract. The greater number of the fibres cf the horizontal tract seen in the drawing can be be followed caudad to the root of the fifth nerve. They arise in processes of the large cells shown at *a*, Fig. 5, of the same plate and are doubtless homologous with the giant cells of the mesencephalic nidulus of the trigeminal nerve seen in all classes of vertebrates. The fibres from the horizontal cells above referred to pass cephalad and seem ultimately to curve peripherad and enter a meshwork produced by the ental ganglion cells. That these horizontally placed cells are homologous with the ental nerve cells is rendered probable by the fact that at the meso-caudal end of the tectum such cells are numerous (Fig. 11) and are obviously related with the ental series. In a few cases two processes were seen passing, one to the right and the other to the left side of the optic lobe. In this region it could be readily proven that they have no relation to the large, deeply staining and agglomerated fibres of the mesencephalic root of V. Fig. 9 illustrates one of many instances where the cell lies entirely above the ental ganglion layer. It is not at present possible to say whether such cells represent the superficial layer of large ganglion cells characteristic of the tectum of fishes. If so, it would seem natural to suggest a common origin of the two sets of tectal cells.

The chief differences between the structure of the tectum in fishes and reptiles seem to grow out of two elements. First, the tectum is relatively much thicker in the latter and the elements are consequently much more crowded; second, the layers do not preserve the discrete character observed in the lower animals. There is a fusion of the several layers, especially the layer of fusiform cells, which in fishes lies at a little distance from the ventricle, is in *Tropidonotus*, for example, dispersed among the other layers. The layer of large ganglion cells lying beneath the superficial optic tract, is also dispersed throughout the greater part of the thickness of the tectum. The above changes necessitate a greater dispersion of the fibres so that the latter no longer occupy distinct concentric bands or zones.

Judging from the specimens examined, the young of reptilia retain the concentric arrangement much more perfectly than the adults. As for example the young *Aspidonectes* figured in Vol. I. The following description of the tectum is given by Sanders.[1]

"The structure of the tectum lobi optici differs in different parts of its extent; taken at about the centre of its arch, it shows seven layers, commencing at the outside. The *first layer* consists of finely granular neuroglia, placed in immediate contact with the pia mater covering the tectum. The *second layer* consists of coarse fibres, apparently transverse but really oblique, that is, going in a direction between transverse and longitudinal; this layer contains sparsely distributed fusiform cells, with their long axes placed radially. The *third layer* consists of granular matter, with closely packed fibres, arranged radially so as to give it a smoothly striated appearance. The *fourth layer* has the radial fibres not very closely placed, and the remainder of the

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[1] *Op. cit.* p. 751.

layer consists of obliquely directed fibres, as in the second layer. The *fifth layer* consists of transverse fibres derived from the crura lobi optici. This layer is clearer in color than the remainder of the tectum, owing to the absence of granular matter, and also to the fibres not becoming so readily colored as the other parts of the tectm; some radial fibres run across this stratum also. The *sixth layer* consists of small cells arranged on branched stems which are prolonged into the radial fibres occurring in the other layers. The *seventh* is a layer of connective tissue of varying thickness in different parts of the tectum; it forms on its external edge a support for the cells of the sixth layer, and internally terminates by a single layer of epithelial cells, which forms a smooth surface towards the ventricle of the optic lobe; this ependyma forms a support for the radiating fibres of the crura lobi optici in their passage from the torus semicircularis to the tectum; this connective tissue is composed of an inextricable network of fibrillæ derived from the epithelial layer of cells.

"The cells of the sixth layer are of two different forms; those situated on the inner edge, which make the terminal enlargement of the radial fibres, and those of the deeper part of the stratum, which are attached to the sides of the fibres of the first, like grapes to their stalk. The cells which make up the inner row of this layer may be described as fusiform, oval, or rhomboidal in shape; they generally show a distinct oval nucleus, in which also a distinct spot-like nucleolus is visible; they vary in length from 0.010 millim. to 0.015 millim., and in width from 0.002 millim. to 0.005 millim; the connective tissue of the seventh layer is attached to the inner end of some of the cells, while their outer end passes off into a fibre which runs radially toward the external surface of the tectum and probably extends as far as to the second layer. The fibres of these cells have a tendency to run in bundles formed of several united together; the bulk of this stratum is made up of cells of a smaller size than those described, and generally more rounded; these are attached to the fibres of the former cells, sometimes by a short stalk and in other cases they are sessile; they usually measure 0.004 millim by 0.003 millim., with but little variation in size. There is present in most cases a distinct nucleus, which is generally rounded, but sometimes it presents a tendency to the oval form. About ten or twelve of these cells occupy the thickness of this sixth layer ; toward the anterior part of the tectum this layer passes continuously into the fornix

"The other species of nervous elements in the tectum is found in the second layer; these are long, fusiform, cell-like swellings of the radial fibres, which are finer at the inner end than at the outer; it is somewhat difficult to measure their length owing to the gradual transition between the fibre and the cells, it may however be said to vary between 0.018 and 0.040 millim.; the width is more constant, being seldom more than 0.005 millim., but occasionally reaching as much as 0 007 millim.; the nucleus measures about 0.005 by 0.003 millim. These cells are not enclosed in a space, but the neuroglia is in apposition to their external surface. The fibre which passes from the inner end of these cells is the finer, and can be traced into the smoothly striated third layer; the fibres from the sixth layer can be traced into the same stratum from the other side, from which circumstance the presumption arises that the small cells of the external layer stand in connection with the fusiform bodies just described. Stieda places these cells in his third or striated layer, and considers them to belong to the neuroglia 'Grundsubstanz.' This does not seem to be quite correct; they are situated, in fact, in the layer which he terms 'die äussere Langsfaserschicht.' Their nervous character can scarcely be doubtful ; they resemble in fundamental structure the cell-like swellings on the fibres of the olfactory lobe, and also the Purkinje cells of the second layer of the cerebellum, as the latter would appear if drawn out and stretched so as to be made long and thin. The outer processes of these cells can be traced under favorable circumstances into the outer finely granular layer of the tectum."

With reference to this account, which is laboriously detailed, it must be admitted that many of the discrepancies encountered are to be referred to the effects of the sudden bath in absolute alcohol.

The following is a condensed account of the tectum opticum of *Acipenser* derived from Goronowitsch:

The tectcum opticum of the sturgeon has a characteristically laminated structure common to all vertebrates. Three layers are distinguished beginning from the periphery. The *outer layer* has a granular fibrous structure and in its outer portion contains the thick fibres of the optic nerve. Beneath this in cross section there appears a concentric fibre layer. Throughout the entire layer are scattered circular elements. Besides the concentric striation there is a radiating system of fibres a part of which are formed by the processes of the deeper cell-layer, while a much larger portion is apparently derived from optic tract fibres which turn ventrad. The minute relations of these fibres were not investigated. The *second layer* is formed of two or three rows of granular cells (Körnerzellen). These cells send their processes perepherad. Between the series of cells of this layer is a system of longitudinal fibres not further determined. The *third layer* consists of the epithelium of the ventricle. Mesad the two halves of the tectum are connected by a transverse commissural system forming the continuation of the concentric fiber system of the external layer of the tectum. Between the fibres of the commissure are a vast number of granular cells. The commissure is more strongly developed cephalad where it passes into the commissura posterior. In the cephalo-mesal part of the tectum are a number of large rather closely set ganglion cells whose fine processes pass radially toward the surface of the tectum, where they seem to pass into connection with the optic fibres. These cells are obviously the large ganglion cells desribed by Rohon under the name Dachkerne in Selachii, in which group they are restricted to the middle of the tectum and extend farther caudad than in the sturgeon where they are limited to the anterior portion.

Where the optic tracts pass into the tectum there is no division into anterior and posterior bundles.

VIII.—*The nidulus geniculatus externus*, which appears on the surface of the brain as an obvious protuberance or "corpus geniculatum," is always present but not always obvious. On plate XVII, Vol. I, Fig. 4, this projection appears as a small tubercle adjacent to the optic tracts and cephalad of the hypoaria. It was described by my brother, in the paper alluded to, its relations are more clearly seen in the cross-section, Fig. 8. We recall no other instance where it is so distinctly obvious upon the surface as in the cat fishes. It is bounded cephalad by the optic tracts and tract of the transverse commissure, is traversed by the ventral commissure, is bounded dorso-mesad by the peduncles and caudo-laterad by the tuber and hypoarium. It sends well-defined fibre tracts to the dorsal peduncle.

The structure of this nidulus is difficult to clear up. Consisting as it does of a meshwork of fibres from various sources and cells of much the character of those of the lateral aspects of the cerebrum, it is hard to follow the connections with certainty. The fact that the commissura ventralis passes through it and divides within it, suggests that it receives fibres from the brachia optica. That a strong contingent derived from the cells of the geniculatus itself pass to the dorsal peduncle, seems to be beyond question. A peculiarity of this body in fishes is the development of a curiously specialized peripheral cell-cluster.

The isolated position of the geniculate body in Amiurus, especially the young fry, makes this brain a very useful one. It is easy to trace a strong branch from the dorsal peduncular tract into its substance and to follow some of the fibres into actual connection with the cells, which resemble in size and appearance those of the hypoaria. There is a curious area on the cephalo-dorsal aspect, where a depression of the surface indicates the locus of a group of peculiar elongated cells of larger size than the others which radiate entad from this modified surface. The appearance is so like that of the ependyma in certain ventricular areas that a suppressed diverticle of the ventricle was suspected. This seems excluded by the position and closer inspection of the cells shows that they resemble those of the superficial layer of the hypoaria. Among the cells are several of the peripheral expansions of the ventricular epithelium so conspicuous in the tectum. Each of the cells gives off two fibres which have not been traced further. A similar superficial area occurs in *Lucioperca*.

From the examination of horizontal sections of *Haploidonotus* it seemed probable that fibres from the ventral commissure connect with the peripheral fibre of the superficial cells, while another branch is given off to divide among the protoplasmic processes of the cells, whose connection with the dorsal peduncles is obvious. The transverse commissure seems to have no relation with the geniculatus. In transverse sections of the drum the larger cells are not restricted to the periphery. In species with large optic nerves the development of the geniculatus is apparently somewhat more prominent than in others. In *Cycleptus*, for example, it is better developed than in the buffalo-fish. In *Hyodon*, it is enormous and there is an imperfect concentric arrangement of the cells. In higher vertebrates, as all reptiles, the geniculate nidulus is entirely cut off from the surface but retains the curious peripheral pseudo-epithelium and is enveloped by a cortical mass of large switch cells which are likewise prominent in birds. The geniculatus itself contains the same plexiform reticulum of blood-vessels so characteristic of the nidulus ruber. The latter is also well-developed in the turtles and has a peripheral zone of pseudo-epithelium of bifid nerve-cells. The fibre connection with both ruber and geniculatus are the same in reptilia as in fishes.

The microscopic structure of the *nidulus geniculatus* can be more clearly made out in horizontal sections of the eel, whose plane is oblique laterally, but approximately horizontal longitudinally, so that the connection with the fibre tracts caudad can be readily seen. The optic fibres cephalad have no connection with the nidulus, but are separated by a connective partition. The concentration of the brain base in this fish has caused the hypoarium to close about the geniculatum latero-caudad, but a sharp line of demarkation remains within. The epithelium-like arrangement of the marginal cells is very obvious and the cells composing it are much larger than the similar ones of the hypoarium. They give rise to two processes, one of which passes cephalo-dorsad, the other caudo ventrad. The latter undoubtedly connects with the dorsal peduncular bundle. The interior consists of cells of similar character, though they are frequently tripolar, the third branch dividing into numerous branchlets associated with the lateral twigs of other cells. The suggestion that the ganglion is a switch station, is the first to arise, and if the fibres of the ventral commissure (caudal brachium tract) actually end in the nidulus, the physiological significance is not difficult to make out. In transverse sections of the same region fibres from the dorso-cephalic region can be followed to their union with one of the processes, while in the meso-ventral portion connection with the ventral commissure is scarcely less obvious.

IX. — *The colliculus and fasciculus lateralis.* The colliculus is a more or less hemispherical projection into the optic ventricle from the ventro-caudal and mesal wall. The development of torus and volvula have great influence on its form. In the drum the colliculi are very distinct and are separated by the above mentioned structures very completely. The substance of these bodies consists of a maze of fibres and small cells in which no special tracts or niduli are noticeable. A coating of fibres on the cephalo lateral surface has been called the stratum zonale, but most of these fibres pass into the fasciculus lateralis, (Fritsch) which is the only prominent tract rising solely in the colliculi. This large tract is very direct and unambiguous and may be followed far caudad, as will be seen hereafter. Some fibres from the tectum may enter the meshwork, but they are ill-defined. Laterad the colliculi are bounded by the decussating fibres from tectum to cerebellum which also pass obliquely through it; caudad by the "Uebergangsganglion"; ventrad they lie obliquely upon the crura and caudo-laterad of the thalamus centres of the posterior commissure region. From the very base and lateral aspects of this body appear to spring the caudal brachia or rather those fibres which pass with the ventral commissure tract and on into the cinereum. Most of these brachial fibres remain on the caudo-lateral aspects of the colliculi ectad of the of the lemniscus and reach a higher level, gradually passing between the lemniscus bundles into the caudal part of the colliculus where, unlike the fore part, is a distinct mass of concentric cells adjacent to the Uebergangsganglion. The best ideas of the relations of the colliculus may be gathered from horizontal sections like Figs. 3, 4, Plate V. In Fig. 3, some fibres of the fasciculus lateralis have already accumulated. Figs. 1 and 2 indicate the subsequent course of the optic tracts and brachia. The fasciculus lateralis was correctly described by Fritsch, who adds that it is very distinct and not to be confused with any other. It ends in the formatio reticularis of the medulla. Mayser considers it the continuation of the lateral column of the cord. At the level of the tuberculum acusticum it receives large accessions. He recognizes no homologue in the mammalian brain. (p. 516.)

X.—*The pes pedunculi.*

1. *The hypoaria*, which afford the most characteristic peculiarities of the fish-brain, have been interpreted in various ways. Haller called them "olfactoria inferiora" or "tubercula reniformia." Cuvier called them "lobes optiques," while Mayer compared them to a combined thalamus and striatum. Hollard regarded them as the specific equivalent of the striata, basing the opinion on the observation (the correctness of which was denied by Vulpian) that the peduncular fibres from the corona radiata terminate in their substance. It is only necessary to refer to the view of Girgensohn, that the two hypoaria constitute a modified hypophysis, as the hypophysis is easily discovered in any fish. Carus considered them the equivalent of the tuber cinerum, while most recent writers, including Fritsch and Sanders, seem to incline to look upon them as more or less specific homologues of the mammillary bodies or albicantia. Stieda, with characteristic caution, refrained from too definite a reference, but Fritsch is very positive in claiming that "The lobi inferiores, in spite of their enormous extent, have no more complicated structure than the corpora albicantia. The organization of these organs is related and supports the homology as does the external form and position."[1] This author claims that the hypoaria resemble the albicantia in the fact that multipolar ganglion cells of medium size resembling those of the cerebrum occur in large numbers irregularly dispersed in a neuroglia net.

"Moreover a system of fibres homlogous with the fornix descends from the torus longitudinalis and, passing through the corpus rotundus, enters the hypoaria and from the same body a bundle emerges with a curved course and passing about the corpus rotundus loses itself in the thalamus" (colliculus).

Sanders describes the cellular structure as follows:

"The parenchyma of the hypoaria is composed of finely granular neuroglia, in which the ramifications of extremely small fibres form a network of inextricable tenuity. In the neuroglia bundles of nerve-fibres radiate from the posterior and upper side in distinct and well-formed cords. The nerve cells occur throughout the neuroglia scattered singly, but increasing in num-

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[1] Untersuchungen u. d. Bau des Fischgehirns, p. 24.

ber towards the free margin of the hypoarium. These cells are pyriform in shape; the thicker end is occupied by the nucleus, in the centre of which in most cases a spot-like nucleolus is seen; occasionally, however, this is occupied by a group of granules. Each cell partly occupies a distinct chamber in the neuroglia, into which only the nucleus projects, the pointed end being closely surrounded by neuroglia; occasionally a process, given off from the thicker end, converts them into bipolar cells." "The ventricles are lined by a distinct layer of epithelium, which is a continuation of the epithelium lining the central canal of the spinal cord. They are surrounded by a layer of small circular or pear-shaped cells which extend for some distance into the substance of the hypoaria." "In addition to these small cells others of a much larger size occur, which are situated more particularly under the epithelium of the ventricle of the hypophysis cerebri, and the adjacent anterior edge of the hypoarium; some are pear-shaped, others are expanded at one end and flattened like an enlarged columnar epithelium cell, but they are not of the nature of epithelium, for they lie beneath that layer." It will be seen that more perfect methods greatly modify the above description of the cell structure.

It must be added to the general description of the hypoaria that they are generally double, either obviously so, as in the cat-fish, or divided by the structure into a caudal and cephalic lobe, each having a special cornu. of the ventricle and a peculiar structure.

The comparison made by Professor Fritsch with the mammillaries ceases to have weight when we observe that the entire mass of peduncular fibres in two large distinct bundles enters these bodies and also enters into cellular combination within the substance. The structure of the cells is moreover entirely unlike that of the mammillary bodies. Histologically the caudal lobe of the hypoarium is composed of a cortical and a medullary portion. (In this consideration the corpus rotundus is not reckoned to the hypoaria but to the mesencephalon).

That the fibres of the dorsal tract of the hypoarium are not the direct continuation of the ventral peduncle fibres can in some cases be demonstrated. Where the section falls in a plane parallel with these radial fibres the bundles can be traced quite to the vicinity of the periphery, where the separate fibres can be traced to processes of the large cells. (Plate IX, Figs. 6, 7, and 8.) In like manner the deep cells give off branches to these bundles. It is not easy to be sure whether the second branch of the cell passes directly into an axis cylinder or first forms a reticulum. The later is hypothetically more probable, while in some cases the appearances would justify the belief in a direct continuity. The large cells of the medullary portion of the hypoaria seem almost uniformly to give off three main processes and present the appearance of bifurcation or fusion of tracts. They are almost certainly to be understood as the connecting nodes between the dorsal and ventral peduncles. In many cases the actual fusion of two axis cylinders may be observed in one of these cells. In cases where the tracts cross at a right angle the connection is especially evident. Study of this region in turtles shows that the structure is identical although there is no trace of hypoaria in the form of expansions of the base of the brain. The structure of the hypoaria is so peculiar that it cannot be confused with any other. It amounts therefore to a demonstration of the truth of our view as to the nature of the hypoaria to discover exactly the same structure in the pes pedunculi region, i. e., the narrow portion of the mesencephalon caudad of the cinereum. Moreover the ventral peduncular fibres can be followed into actual connection with the peculiar bifid cells just mentioned, and the other process passes either to the nidulus ruber or the large cells connecting with the cerebellum. Still again, we have traced the origin of the hypoaria embryologically as a product of elaborate folding of the brain base consequent on the enormous folding of the roof of the mesencephalon and cerebellum These folds subsequently are nearly obliterated but the hypoaria remain as evidence of the extrusion of important areas morphologically pertaining to the region in front of the ansulate commissure. The cells arise as products of proliferating epithelium as well as probably migrants from other regions.

2. *The nidulus ruber and nidulus niger.* In construing the region back of the infundibulum it will be well to keep in mind what is known and what is suggested with greater or less probability in the case of mammals. We are relieved of one serious

drawback in homologizing these structures by recognizing the mammillaria in their normal position immediately caudad of the infundibulum, leaving us free to interpret the hypoaria in accordance with their position and contained structures. In other vertebrates the region between the tuber and the pons is occupied ventrally by the pes pedunculi or crusta. We have fortunately a very definite landmark in the decussation of the middle peduncles of the cerebellum, which is exceedingly distinct lying at and just caudad of the exit of the oculomotor nerve. In this region the greater number of the ventral peduncular bundles end. Says Ranney, "Some of the efferent fibres of the cerebrum probably leave the direct tract of the projection system within the region of the pons, passing to the cerebellum." "Cross sections of the region of the pons reveal the fact that the transverse fibres of the processus cerebelli ad pontem may be divided into three sets, as follows: 1, a superficial layer; 2, fibres which interlace with longitudinal fibres escaping from the crus; 3, a deep seated layer. The superficial and deep-seated layers appear to be perfectly independent of any association with the fibres belonging to the middle projection system of the cerebrum (those of the crusta and tegmentum cruris.) Meynert, however, brings forward certain reasons, based upon a minute study of the general relations of these layers, which apparently lend support to the view that the fibres of these strata are in communication with nerve cells imbedded in the pons, and that certain fibres are likewise joined to these cells, and that the two sets of fibres are thus brought into communication with each other." This assumption we are fortunately able to demonstrate in the most satisfactory way. The fact that the ventral peduncular bundle, whose fibres have been traced to the cells of the fore part of the hemispheres, find their apparent termini in the posterior portion of the hypoaria, is sufficient to point to the latter as expansions of the pes pedunculi or, specifically, the crusta. In all animals higher than fishes there is a layer of densely staining matter separating the crusta from the tegmentum, the *substantia nigra*. In all cases where we have examined it this region has a nidulus of very peculiar cells, whose numerous branches include at least two axis-cylinders and apparently more. This the author has called in the reptilia, nidulus niger.

In mammals the nidulus is less compact and such cells are scattered widely in the region. In the corresponding region of fishes, dorsad of the ventral peduncular tract and separating it from the tegmentum with the dorsal peduncular fibres, is a very strongly developed nidulus forming the medullary part of the hypoaria and the transition between the three sets of fibres; viz., the ventral and dorsal peduncles and the tract to cerebellum. The origin of the fibres can be seen with all desirable distinctness. A comparison of such a figure as Fig. 72, in Edinger's Lectures on the Nervous System, with a section through the posterior part of the hypoaria of fishes, reveals complete similarity. The apparent differences grow out of the shortening of the axis by which the enormously developed optic tectum is crowded backward, the cerebellum forward and the aqueduct is expanded in such a way as to puff out the sides of the crusta. The nigra and nidulus ruber sustain normal relations and fibre connections. The position and character of the niduli of the tegmentum are especially helpful in determining homologies in this region.

The most characteristic of these cell masses has in all groups of animals a peculiar suffused color which has earned for it the term red nidulus (nucleus ruber.) In man this is composed of granular masses and nerve cells. The processus e cerebello ad testes or superior peduncle of the cerebellum comes into close relation with it and the region is filled with large multipolar cells which are closely associated with very numerous blood-vessels. Meynert describes the branches of the cells as running in the walls of the vessels. Such a peculiar structure is not easily mistaken if present and what we have to add respecting the nucleus rotundus of fishes will serve to establish the homology.

The nidulus ruber in mammals occupies a conspicuous place in the tegmentum and is mesad and caudad of the corpus subthalamicum or body of Luys. The fibres of the tegmental radiation "lie outside of and above the red nidulus, surrounding about a third of that ganglion like a capsule," (Edinger, p. 94). Passing caudad they form a tract of fibres which is variously known as lemniscus, laqueus, or fillet (schleife). Fibres from the thalamus enter the nidulus ruber. Professor Fritsch describes the body, which we unhesitatingly regard as the homologue of the nidulus ruber under the name corpus rotundus and regards it as a marked peculiarity of the fish brain. Its structure he compares to that of the tuber olfactorius. Fritsch was unable to demonstrate the exact nature of the microscopic structure, though he thought he discovered possible nuclei of ganglion cells amidst the meshwork of fibres and numberless granules contained in the diffusely stained granular mass. That we are more fortunate is due to the method of preparation and staining. Numerous bundles enter it or pass through it, but Fritsch was unable to discover any clue to their relation to the substance of the body, of the nervous character of which he was nevertheless convinced The most conspicuous bundle which enters the mass is that termed by Fritsch the *commissura horizontalis*, which Mayser claims with perfect correctness passes through it on its way to the region of the posterior commissure. But the body is partly surrounded and probably penetrated by a portion of the dorsal peduncles or the homologue, in a general way, of the tegmental radiation. The analogy in position and fibre connections is complete when compared with the nidulus ruber and we shall see that its structure is similar. Sanders describes the structure as follows: "It is composed of interlacing fibres and granules, in which are imbedded cell-like bodies which differ greatly in size, some measuring as much as 0.07 millim. by 0.06 millim., some as little as 0.04 millim. by 0.03 millim.; many are nearly round, others longer than broad; they are composed of loosely aggregated granules of about 0.001 or 0.002 millim. in diameter, which are crowded about the circumference, leaving a space in the centre, which in many cases is occupied by a smooth, oval or pyriform body, having somewhat the aspect of the protoplasm of a cell, but in which no nucleus is observable; sometimes this body is missing in very thin sections, there remaining only a clear space, which it has probably occupied. Capillaries are occasionally to be seen passing through the loose granules of the circumferential portion. What these bodies are I am at a loss to determine, they are about the same size as the larger cells of the spinal cord. The granules also, which compose their cortex, resemble those of the protoplasm of those cells, in size and aspect, except that they are more loosely aggragated; they might be looked upon as cells in which the granules of the protoplasm are more loosely arranged than in an ordinary cell; or the body in the centre might be regarded as a cell, surrounded by a mass of granules for reinforcing or extending its nervous energy. In *Mugil cephalus* these bodies occupy the whole of the nucleus rotundus; but in *Crenilabrus* there is a space left in the center occupied only by granules and a network of fibres [tract of commissura horizontalis! (H.)] In *Crenilabrus* the circumference of this body is bounded by a layer of small cells . . . which are elongate in shape and have a circular nucleus, which contains several granules instead of a single nucleolus. This nucleus often projects from one end of the cell, giving to the latter a high-shouldered appearance; the side of the cell opposite its nucleus ends in one or two processes and is always turned toward the centre of the nucleus rotundus. These cells absorb coloring matter to a greater extent than most others."

Passing now to the structure of the nidulus ruber, which has hitherto baffled all observers, we are fortunately able to reduce everything to simple elements and familiar combinations. The examination with a moderate power (1-5th objective) presents the appearance so frequently described of gelatinous masses, diffusely stained and of granular consistency scattered in the meshes of a neuroglia net, which also abounds in spherical granules. Nevertheless this appearance is entirely illusory. With immersion lenses our sections reveal a definite structure. The neuroglia ground substance seems to be no more highly differentiated than in many other parts of the brain, but it is supplemented by a vast number of nerve fibres which, being chiefly nonmedullated, give a dense appearance to the mass. Blood-vessels are perhaps more numerous than in any other part of the brain and form a complete minute capillary reticulum, which in itself is evidence of tremendous vital activity of some kind. The most striking nervous elements are large multipolar ganglion cells which resemble those of the medullary part of the hypoaria (substantia nigra). These cells give off two or more large axis-cylinder processes, besides a number of small protoplasmic processes, which are soon lost in the substance of the nidulus about the blood-vessels. To these cells the same interpretation may be given as to the similar cells of the nigra and many other regions of this segment, i. e. they are switch cells or reflex stations. In this case we are certainly dealing primarily with sensory fibres, though some of the processes given off may pass to the motor peduncles. These cells are most numerous near the border but are scattered throughout the nidulus. They vary greatly in form and size, but do not become small enough to be confused with the second type. In some cases they are pale and granular instead of deeply stained and rather homogeneous and in such cases it might be supposed that we have a transition to the splotches which give the characteristic appearance to the ruber. This is not the case, however, for these bodies are larger and tend to assume an irregularly polygonal or subspherical shape. The most common cellular elements are scattered in great numbers throughout the whole mass. They have the appearance of the cells of the cerebrum, but vary greatly in size. They are fusiform, with a strong apex process and large, clear nucleus and simple nucleolus. These cells lie in all directions and their nervous processes make up a large part of the reticulum of the body and radiate from it in various more or less definite tracts. One is struck by the fact that these cells vary greatly in the intensity of stain and that they tend to aggregate in clusters with the fibres in the same axis. Using higher powers and becoming aware of the faintness of the stain, in many cases the number of such cells continues to increase until there remain only a few very dense masses which can still be regarded as the representatives of the opaque areas, which are so conspicuous under lower powers. Addressing ourselves to these bodies it is possible to show that these also consist of a cluster of the cells above mentioned, compacted into a mass and ensheathed with neuroglia. In no case which we have examined, where the conservation and staining were perfect, have we failed to demonstrate these cells with nuclei and processes. The color is very faint and we suppose that the staining portion of the protoplasm has been partly extracted and suffused through the cluster. It might also be supposed that these cells, by reason of their compactness, are less accessible to preservatives and stain and therefore shrink more and stain less. Such large vacuoles, as described by Sanders, do not develop when properly treated with chrom-acetic, which seems to be a much better reagent for this purpose than chromic acid. Sublimate might be even better, but has not been employed. (Plate IX, Figs. 9-11.)

In the buffalo-fish and black-horse (American Cyprinoids) the nidulus is very small and elongated rather than circular, but the essential structure is similar, though the fibre-connections are much more obvious by reason of the fact that there is less suffusion and less tendency to aggregation of the cells.

In the channel cat fish the characteristic appearance is lost and the elements appear in a transparent mass with all distinctness. There is much less definite aggregation of the small cells, while the larger ones are among the most distinctive switch cells yet seen. In *Lucioperca* the sections made by me in a Berlin laboratory, were less perfectly fixed because of imperfect appliances and here, for a time, I was tempted to believe in an actual gelatinous glomerule, such as has been described. But sufficient care demonstrates in these sections the same fusion of elements exactly like those surrounding the spots. These cells are larger and more uniform in size than in the drum and for this reason fewer enter any single glomerule. All transitions were observed.

In *Blicca* (a European Cyprinoid), on the other hand, the suffused splotches are absent, although the nidulus is enormously developed. Instead of these glomerules we have beautiful illustrations of the rosette clusters of fusiform cells which the writer has so frequently called attention to as indicating regions of cell multiplication. The entire body retains an embryonic simplicity and is bounded on most sides by a dense zone of radially placed cells of the same sort as those within. The arrangement is precisely such as we have observed in the embryo of *Belone*. That there is no mistake in the identification of the body is proven by the relations of the commissura transversa, which passes through the midst without obvious cellular connection, as in all other cases, the same course being observed in the case of *Lucioperca*, where the glomerulary structure is so evident. In the black-horse (*Cycleptus*) there are the most beautiful examples of this clustered arrangement. In this case also the organ is very large but retains an embryonic character. But instead of a spherical mass with a clothing of densely arranged radial cells, the coating is convoluted, forming a body very like the olives. The position of the nidulus is indicated in Fig. 8, Plate XX, of Vol. I, by the cluster of cells on the dorsal aspect of the hypoaria. In the eel (*Anguilla*) the nidulus ruber is relatively very large and does not have the obvious glomerular structure of the drum.

In *Hyodon* the nidulus is very simple and does not assume the glomerulary phase. Among ganoids the nidulus is diffuse, but has the same structure at least in *Lepidosteus*.

In the young bull pout (*Amiurus*), the nidulus ruber is one of a group of similar masses and, while there is very much less of the suffusion characteristic of the nidulus than in adults, the grouping of cells into rosette-like clusters, the presence of a great number of blood vessels and the interblending of the multipolar switch cells is characteristic. In a somewhat later stage the nidulus becomes more compact and enclosed in a loose capsule of fibres, its cells acquire a radial arrangement, and the gelatinous suffusion becomes marked. The course of the commissura horizontalis through the nidulus, then cephalo-dorsad to a point adjacent to the ventricle, immediately ventrad of the posterior commissure, is easily traced. The ventral pyramidal bundle lies laterad of it, and is also distinct.

In specimens of young *Belone belone* (Scomberesocidæ), measuring between three and four centimeters, the "nucleus rotundus" is already well developed and consists of a nearly spherical body, lying dorsad of the hypoaria. The walls of the sphere are formed by thickly set radial cells of a fusiform type. The apex prolongations extend inward, and at the same time cephalad. The sphere is thus enclosed on all sides except cephalo dorsad, where is a gap through which a strong bundle of fibres emerges. Outside the cellular envelop is a less dense zone. outside of which are numerous fibres of the pyramidal and other systems. Within are numerous blood vessels and a gelatinous mass which also contains some blanched cells, like those seen in adults. There are also a number of the "switch-cells," which connect different fibres. Mesad of this body is a bundle of nerve fibres, which is probably a part of the dorsal peduncular bundle from the cerebrum. From the comparatively sparing embryological material at hand we consider it probable that the whole cell cluster springs from the median part of the optic ventricle (or third), being derived from one of the many clusters of neuroblasts which arise there.

The bundle which emerges dorsad is doubtless the tract of the commissura transversa, together with the specific fibres of the nidulus to the dorsal regions of the thalamus.

The tracts which are associated with the nidulus ruber are the following: The commissura horizontalis tract, which passes through it in a broad curve so that it enters from a cephalo-ventral, and emerges in a cephalo-dorsal direction; 2, a direct medulla tract, springing from the above mentioned at its dorsal union with the nidulus, which passes directly caudad through the loop of the commissura ansulata, etc., and enters the medulla in a cando-dorsal direction; this tract is shown in Figs. 1 and 2, Plate VI., and must not be confused with the cerebellar peduncle dorsad, nor the main body of the dorsal peduncle which lies caudo-ventrad of it; 3, the dorsal peduncle of the ruber, a tract with a mixture of non medullated fibres and cells leading toward the thalamus ventrad of the dorsal part of the com. horizontalis; 4, the dorsal peduncular fibres, embracing the nidulus from all sides except dorsad, so that it is difficult to distinguish special tracts. The fibres passing to the cerebrum constitute a compact bundle. There is a distinct ventral bundle going toward the medulla of the hypoaria (niger), and the tract passing from the medulla in its dorso-lateral aspects in a tortuous course to the caudo-ventral region of the ruber. Other minor fibre tracts may for the present be ignored.

In amphibia the nidulus ruber is not distinct, although it is clearly indicated by Reissner [1].

This mass lies in the homologous position, dorsad of the infundibulum where the latter expands to simulate the hypoaria though they are not hollow. It is described by Reissner as follows: "Es sind übrigens die früher zerstreuten Bundel zu einem einzigen, freilich nicht gang compacten vereinigt, in demselben und um dasselbe liegen körner in grosser Menge." The combination of the various bundles of the thalamus, the accumulation of numerous cells in a meshwork, and the position make the identification probable. It will be observed by a study of the plates accompanying Reissner's memoir that caudo-

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[1] Bau des centralnervensystems der ungeschwänzten Batrachien. Plate VII, Fig. XI.

ventrad of this point the motor bundles of the peduncles gather from the walls of the thalamus.

The figures cited by Prof. Fritsch as the homologues of the "nucleus rotundus" (Fig. XII, C, and Fig. XVI, E.), are certainly not to be so regarded, being, as correctly stated by Reissner himself, bundles of fibres. Furthermore, in both these cases the position is too far cephalad, i. e., in the region of the habena and anterior commissure(!) respectively, the actual homologue, correctly described and located and well figured, was overlooked, (See FRITSCH, Untersuchungen über den feineren Bau des Fischgehirns, p. 59; REISSNER, loc. cit., p. 90.)

In the tailed amphibians there seems to be no very distinct development of this nidulus, though we have examined sections of Menopoma, Necturus, Salamander, etc., with reference to this point.

XI.—*The nidulus subthalamicus* is an irregular mass which lies ventrad and cephalad of the nidulus ruber (rotundus) and adjoins the geniculatus cephalad. It is passed through by the dorsal peduncular fibres, horizontal commissure tract, geniculate tract and others in the most various directions, and is rich in vessels. The microscopic structure consists in a vast number of fusiform cells of small size and Deiters' granules. There are very few of the large multipolar "switch-cells" of the region of the ruber. No strict homology with the nidulus subthalamicus of mammals is intended, but this group includes all the gray matter of the regio subthalamica, and may conveniently retain that name. Embryonic material indicates the composition of the cluster from various niduli. The whole subject of the gray matter of the thalamus and mesencephalon requires subsequent revision in the light of embryology.;

DESCRIPTION OF PLATES.

Fig. 1. (In text.) Diagram of course of the various tracts in the mesencephalic region. The brain is supposed to be viewed from above and the parts are projected upon the horizontal plane. The ventral parts, except a portion of the tuber cinereum, are removed.

Plates A, B, and C of the special fasciculus issued in February constitute Plates I, II and III of this volume.

PLATE IV.

A series of horizontal sections through the ventral portion of the brain of *Haploidonotus*. All important structures were outlined with the camera lucida.

Figs. 1, 2. Sections through the hypophysis, tuber cinereum, and hypoaria. The decussation of the fibres of the epithelium of the hypophysis and the peduncle formed by similar fibres from the saccus are shown in Fig. 2, which also passes through the base of the mammillare and recessessus lateralis of the infundibulum.

Fig. 3. The ventral peduncles are here in section and the *tractus tuberi ad commissuram ventralem* is cephalo-mesad of it.

Fig. 4 contains part of the ventral commissure and the small *commissura superior tuberi.* Peculiar cell-less regions latero-cephalad of the conus præcommissuralis is indicated as the postcinerea.

Fig. 5 passes through most of the interoptic commissures. The tract of the commissura horizontalis appears twice in the section. The medullary part of the hypoarium we have termed nidulus niger, the cortical is a cellulo-fibrous modification of the pes pedunculi.

Fig. 6 occupies a position somewhat dorsad of Fig. 5 and passes through the nidulus ruber (nucleus rotundus). The subthalamicus lies just cephalo-ventrad of the ruber.

PLATE V.

A series of horizontal sections of the brain of *Haploidonotus* farther dorsad than those of Plate IV.

Fig. 1 may be compared with Plate XXV, Fig. 8, Vol. I, but it lies somewhat dorsad.

Fig. 2 lies somewhat ventrad of Fig. 2, Plate XXIV, Vol. I, and the numerals refer to the same tracts to be discussed hereafter.

Fig. 3 is a short distance dorsad of Fig. 3, Plate XXIV. In the latter the reference numbers have the following signification: 1, habena; 2, cephalic optic tract; 3, Meynert's bundle; 4, posterior commissure; 5, tract from commissura horizontalis and anterior peduncle of cerebellum, 6, cells giving rise to Mauthner's fibres; 7, lateral longitudinal fasciculus; 8, caudal brachium, etc.; 9, ganglion layer of the tectum; 10, caudal optic tract; 11, lemniscus; 12, nidulus of cells in a dense stroma adjacent to the lemniscus, 13, nidulus of fourth nerve.

Fig. 4. A section somewhat ventrad of Fig. 3, Plate XXIV, Vol. I. Attention is called to the so-called gelatinous tracts which pass from the torus longitudinalis to the tectum—fibres which must be distinguished from the Sylvian commissure.

PLATE VI.

The figures on this plate are in each case drawn in outline with camera lucida, and all tracts and principal niduli are as outlined with the camera. Only such details as occur in the single section are introduced, except in the case of the dotted lines indicating in Fig. 1 the course of the combined anterior peduncle of the cerebellum and tract of the commissura horizontalis which would appear in the section were it not slightly oblique.

Fig. 1. Longitudinal section of the entire brain of *Haploidonotus* near the median line. The tectum is not cut, as it lies laterad of the plane of section. The parts are named upon the drawing. For the region of the habena compare Fig. 4. The *nidulus rotundus* (or ruber) lies in close juxtaposition to the *nidulus subthalamicus*. The *corpus geniculatum* lies well ventrad. The medullary part of the hypoarium with its three-fold fibrous connections is here termed *nidulus niger*.

Fig. 2. A similar section somewhat laterad, passing through the mammillare (*Mam.*)

Fig. 3. A similar section farther laterad, illustrating especially the concentric arrangement of the tectum fibres in passing through the colliculus.

Fig. 4. A portion of a similar section through the habena, more highly magnified.

Figs. 5, 6. Two transverse sections through the mesencephalon of very young specimens of *Belone*, the former at the *nidulus ruber* the latter at the exit of the third nerve.

PLATE VII.

Fig. 1. A portion of a transverse section of the tectum opticum of *Lucioperca*. The section is from the middle of the left side. The epithelial cells are rendered somewhat confused by reason of a slight obliquity and the tearing due to cutting. Above the ental ganglion layer (2) the walls collapse and the interspaces are filled with the stroma. For details see text.

Fig. 2. A portion of one of the epithelium cells and an adjacent cell of the ental ganglion layer more highly magnified.

Fig. 3. A portion of the ectal ganglion layer.

Fig. 4. The termination of the fibres of the ectal ganglion layer in the reticulum of the ectal zone.

Fig. 5. Portion of the superficial part of the tectum in *Lepidosteus*, highly magnified to show the termination of the epithelium frame work.

Figs. 6, 8, 9. Horizontal sections in the region of the habena from *Blicca Bjkorkna*. Fig. 9 especially illustrates the origin of the "gelatinous tracts" in the torus and their passage to various parts of the tectum.

Fig. 7. Transverse section through the habena of *Lucioperca*. The commissura transversa occupies the ventral part of the section.

PLATE VIII.

Figs. 1, 2. Longitudinal sections of the brain of young specimens of *Belone*.

Fig. 3. Longitudinal section of the brain of fry of *Trutta fario*, with a portion of the skin and nasal sac. *S. b.* sensory buds of skin; *N. s.*, nasal sac; *L. v.*, lateral ventricle; *D s.*, dorsal sac; *Ep.*, epiphysis; *H.*, habena; *Tl.*, torus longus; *To.*, tectum opticum; *On.*, optic nerve; *P. tr.*, pyramidal tracts; *P. tr. v.*, ventral pyramidal tract; *Hypo*, hypoarium; *V. c.*,velum caudale; *Mb.*, Meynert's bundle.

Fig. 4. Transverse section through epiphysis. showing its connection with the third ventricle.

Fig. 5. Cells from *a*, Fig. 4 especially showing intimate connection with capillaries.

Fig. 5*a*. Similar cells near ventricle.

Fig. 6. Cells from *b*, Fig. 4.

Fig. 7. Cells from the habena from section preceeding Fig. 4.

Fig. 8. Horizontal section, brain of *Haploidonotus* to show the Sylvian commissure (*Com. syl.*) and gelatinous fibres of torus (*gel. f.*)

PLATE IX.

Histological details of the midbrain.

Fig. 1. Portion of a transverse section of the tectum opticum of nine days old *Trutta fario*.

Fig. 2. Section of a similar brain longitudinally of the tectum, especially designed to show the termination of optic nerve fibres in the cells whose apex processes divide in the ectal reticulum.

Fig. 3. A small portion of a similar section to demonstrate the connection of the ganglion cells with the descending tract.

Fig. 4. A portion of the nidulus niger in the drum, illustrating the form of the switch cells in the dorsal part of the hypoaria.

Fig. 5. Similar region of perpendicular section to demonstrate threefold connection, i. e., with region of ventral peduncles, tract to cerebellum, and dorsal peduncles.

Fig. 6. Marginal cells of hypoaria in the drum.

Fig. 7. Cells from the ventral part of hypoaria in nine days old *Trutta fario.* The ventral peduncle fibres are at the right.

Fig. 8. Cells of the marginal part of hypoaria in the drum, showing connection with ventral peduncles and probable secondary branch to anastamose with cerebellar and dorsal peduncle.

Fig. 9. Region of nidulus ruber (catfish ?)

Fig. 10. Portion of the nidulus ruber (*Lucioperca.*)

Fig. 11. Portion of nidulus ruber (*Haploidonotus.*)

PLATE X.

This plate is intended to illustrate the extreme simplicity of the histological elements in the Urodela. The figures are all derived from a series of horizontal sections of *Menopoma alleghenensis*, stained with hæmatoxylin. The stain is a nucleary selective agent in this case but with sufficient care the cell body and processes can be made out with considerable detail. *Figs.* 1–4 are horizontal sections through the cerebrum and mesencephalon at different levels. The letters in Fig. 2 refer to areas shown below on an enlarged scale.

Fig. 5. Portion of optic lobes and thalamus with postcommissura enlarged from Fig. 2. The right side of the figure indicates a few isolated cells and fibres in a semi-diagramatic way for reference, the left side is drawn with a camera although the outlines of the cells are not given with precision. *H.* portion of the left hemisphere, *i*, habena and portion of the tænia, *g*, tract of superior commissure, *c*, centre of origin of Meynert's bundle? *e*, posterior commissure, *a*, large cells supposed to be homologous with the mesencephalic nidulus of the 5th nerve, *b*, tract, *f*, optic tract.

Fig. 6. Cells from the frontal region, point indicated by Fig. 2*c*. Drawn with 1-12 obj.

Fig. 7. Cells from the habena, point indicated at Fig. 5, (6*d*). Drawn as above.

Fig. 8. Cells from meso caudal part of the hemisphere, point indicated in Fig. 2*e*. as above.

Fig. 9. A cell from the tectum opticum above the general level of the ganglion layer. Compare Fig. 12, as above.

Fig. 10. Cells from the Meynert's nidulus, point indicated in Fig. 5*c*.

Fig. 11. Cells from the caudal part of tectum near the mesal line. The fibres are parallel with the ventricle. A bifurcated fibre is indicated.

Fig. 12. A section from the venticular epithelium to above the ganglion layer. Drawn with a camera lucida and 1-12 objective. Pains was taken to indicate no more than could actually be seen in this section. Those cells in which no processes were drawn have doubtless lost the cell body by the solvent action of the reagents. The cells with horizonal processes seem to belong to a tract distinct from that indicated at *a*, Fig. 3 and *b*, Fig. 5. A capillary with two blood corpuscles is included in the section.

PLATE XI.

(For explanation see page xiv).

PLATE XII.

Figs. 1–4. Combination drawings of transverse sections of the brain of the channel catfish. The left side is drawn from a section farther cephalad than the right and in Figs. 1–2 the outline of the opposite half is superposed for comparison.

Figs. 5–8. Longitudinal sections through the brain of *Scorpæna*.

RECENT VIEWS WITH REFERENCE TO THE STRUCTURE OF THE NERVOUS SYSTEM.[1]

PROF. HEINRICH OBERSTEINER.

The nervous system, in distinction from all other organs of the animal body, occupies a peculiar position. This applies both to the central system and to the peripheral system, anatomically and physiologically inseparably connected with it. Most organs have definite functions which may be performed in the same, or nearly the same manner by even the smallest portions of the organ. We may assume that every liver cell participates in the elaboration of bile, that every muscle fibre contracts as a result of the stimulus applied to it. But what a diversity of function has been indicated for the nervous system! Yet we know that the whole physiological activity of the organism is directed and regulated by the nervous system; to this may be added certain peculiar functions, in fact, the highest and noblest functions of the whole organism.

It is, moreover, conceivable that this circumstance finds its expression in the complexity of the inner structure of the nervous organs. The difficulty, therefore, of securing definite knowlege of these relations is materially increased. From this it follows that in the anatomical treatment of the nervous system we meet with the unpleasant necessity, even in text-books on the systematic anatomy of the central nervous system, of entering into the discussion of fine details visible only with the microscope. And conversely histology must contain topographical-anatomical facts, while, in the case of bones for instance, it describes their structure in general, but not individual bones, their position and form.

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[1] Translated from "Naturwissenchaftlichen Rundschau," Jahrg. VII, No. 1 and 2, by C. Judson Herrick, Professor of the Natural Sciences, Ottawa University.

It has, however, become apparent that even the coarse architecture of the nervous system cannot be rightly understood unless clear views of the anatomical and physiological significance of the finest elements which constitute these organs can be gained. In this connection, the investigations of recent years have brought to light much that is new; and, although we are still far from definitely proven, generally accepted results, yet there has been a clearing of the conception on very essential points. It therefore seems appropriate to give at this time a brief review of the most recent investigations in this field.

As *histological elements* which contribute to the structure of the nervous system, it is customary to distinguish nerve cells (ganglion cells), nerve fibres, epithelium cells, blood-vessels, and, finally, those tissues which I shall comprise under the term connective tissues. Only the two kinds of tissue first mentioned commonly rank as nervous elements, in distinction from the others, which are not nervous. This distinction, however clear and simple it may seem, can be strictly maintained only on the ground of convenience, not as rigidly correct. The epithelium cells of the lining of the ventricles and the nerve cells arise from the same embryonic structure [*Uranlage*], the neuro-epithelium. His has demonstrated in the greatest detail (Arch. f. Anat. u. Phys., 1889,) how in the early stages of development the epithelium cells of the medullary tube are separated into two forms, of which the one corresponds to the spongioblasts, the permanent ventricular epithelium, the other to the germinal cells of the neuroblasts, or ganglion cells. When we recall that many (Klausner, Freud,) have followed processes from the epithelium cells into the bundles of nerve fibres and that these processes take certain staining reagents (e. g. gold), just as nerve fibres do, we find another justification for believing that the position can be no longer unconditionally maintained that the epithelial cells of the medullary tube are sharply separated from the nervous elements.[1]

But, on the other hand, more recent works (I refer to the very latest of Retzius, Verh. d. biol. Ver. zu Stockholm, 1891,

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[1] See evidence in this number, p. 31, seq., that the so-called nerve fibres of the hypophysis are simply prolongations of epithelial cells. [Tr.]

and Lenhossèk, Verh. d. anat. Gesellsch., 1891) teach that the ependyma cells, as the epithelium in question is called, have a very considerable share in the formation of a supporting framework, which extends through the central nervous system from the central ventricle to the surface clothed with the pia mater.[1]

The supporting substance, in which I include everything which is neither nerve substance nor vessels, is certainly not to be regarded as a single kind of tissue. It is at least probable, though not generally accepted, that real connective tissue participates in the formation of this supporting substance, especially of the larger septa. Much of that which has heretofore been described as neuroglia—a finely granular mass, or intercellular substance, which fills the larger and smaller interstices between the other elements of the central nervous system—proves, under improved methods of investigation,. to be a felt, or network, of the finest nerve fibres. Here belongs also Leydig's dotted substance in the lower animals. But even the familiar spider cells of the central nervous system, Deiters' cells, which are an essential ingredient of supporting tissue, are not so far removed from the nervous elements as has been heretofore supposed. Even by the earlier investigators it it was assumed that the glia cells also take their origin from the ectoderm; but it was reserved for Rámon y Cajal (numerous works in recent years) and Lenhossèk accurately to describe them as arising, like ganglion cells, from the epithelium of the medullary tube. Consequently the distinction between ganglion cells and glia cells must be dropped; and one really finds structure in the central nervous system which show intermediate stages. In this connection I mention the so-called "granules," which are met with in the bulbus olfactorius, in the retina, but especially in larger numbers in the granular layer of the cerebellum. Recent investigations, especially of Rámon y Cajal (Internat. Monatsschr., 1890) and Kölliker (Zeitschr. f. wiss. Zool., 1890), have shown that most of the granules in the granular layer are of nervous nature and are in connection with nerve fibres. On the other hand their nuclei are stained deep blue by hæmatoxy-

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[1] Illustrations of the structure here referred to may be seen on p. 45 and Plate VII, Fig. 9 and Plate X, of this number. [Tr.]

lin, a peculiarity which they share with all non-nervous nuclei; while the nuclei of the larger nerve cells do not take up hæmatoxylin. Here allusion may be made to preparations of Weigert, who succeeded in staining the neuroglia separately by a method the details of which have not yet been published (Anat. Anz., 1890).

The instances adduced teach us that much of the most recant investigation makes it appear at least possible to place many of the tissue elements hitherto looked upon as distinctively non-nervous nearer to the nervous elements histologically and especially genetically.

I will, however, in what follows limit myself to those contributions which during the last few years have promoted our knowledge of the significance of the pure nervous elements, and I will adduce the most important facts which they teach us concerning the structure of the nervous system as a whole.

It is customary to distinguish nerve cells and nerve fibres. The histological idea of a nerve cell is especially hard to define. If we remember that every functional nerve cell is directly connected by one of its processes with at least one nerve fibre and it is impossible to decide where the process becomes transformed into the nerve fibre, it seems very appropriate to consider the nerve cell with the fibres springing from it as a unit. Every nerve fibre, however, is said to break up up at the end opposite the cell into a fine terminal tuft, or brush (*Endbaeumchen*, Kölliker), so that we arrive finally at the conclusion that the whole nervous system consists of numerous nerve units, or neurones (Waldeyer, deutsch. med. Wochenschr., 1891). Every nerve unit consists of three parts: the nerve cell, the nerve fibre, and the terminal brush. These three elements will now be treated separately.

I. *The nerve cell.* I have already remarked that it is scarcely possible accurately to define this histologically. The views, moreover, with reference to the anatomical and physiological significance of the nerve cell are no longer separated, as has been the case heretofore. Max Schultze had pointed out (1869) the fibrillary structure of nerve fibres; i. e. of the most important and uniformly present element of such fibres, the axis-cylinder. These fibrillæ may be followed into the cells, where they are easily made visible by a new method (Kronthal, Neurol. centralbl., 1890). In the cells they suffer a certain change of position and pass out by way of other processes. These primitive fibrillæ are thus the essential conducting elements. Very different, however, is Nansen's conception (Anat. Anz., 1888). He considers that the axis-cylinder consists of a great number of closely arranged primitive tubes. These are composed of exceedingly fine connective tissue sheaths (spongioplasm) with viscous contents (hyaloplasm). The compressed cells of the walls between the primitive tubes were mistaken for primitive fibrillæ. It is not, therefore, the latter which are to be regarded as the physiologically important elements of the axis-cylinder, but those parts which were before taken to be a fluid intermediate substance. This tubular structure, in accordance with Nansen's views, appear also to the bodies of nerve cells.

Every nerve cell possesses at least one process; but such unipolar cells are exceptional and we have concerned ourselves with those cells only from which several processes may be observed.

As is well known, Deiters (1865) first suggested that all central ganglion cells have two distinct kinds of processes: an axis cylinder process and a variable number of protoplasmic processes. With reference to the first, Deiters had previously maintained that it posses directly into a (medullated) nerve fibre. This opinion has been shared by almost all investigators until now, and apparently properly so. Really, however, such an indubitable passage into the nerve has hitherto been observed only a few times (e. g. Koschewnikoff, Freud); and even if the axis-cylinder process, chief process, or nerve process can be differentiated from the protoplasmic processes by the appearance which it presents, especially after treatment with Golgi's impregnation with silver, still the conscientious investigator will be in doubt to which of the processes he should give the precedence in the case of very many cells observed under the microscope—nay, rather, in the case of most of them. I do not then consider quite just and candid the reproduction, in many illustrations, of nerve cells strictly true to nature, even to the color (black) produced by silver impregnation, while those processes only which impress the author as axis-cylinder processes are printed in red.

These axis-cylinder processes may be divided into two distinct types. Either they give off isolated lateral twigs merely, without thereby losing their individuality, until finally they become axis-cylinders of medullated nerve fibres (motor type); or the axis-cylinder process breaks up again and again into the finest fibrils without passing into the axis-cylinder of a nerve fibre (sensory type). If, however, in the case of a cell of the sensory type the axis-cylinder process does not pass directly into a nerve fibre, then by that very fact it is deprived of the chief characteristic which makes it an axis cylinder process. The relation of the axis-cylinder process is in this case exceedingly similar to that of the so-called protoplasmic-processes.

That the protoplasmic processes (*Dendriten*, His) break up by repeated branching into very fine twigs, may easily be shown by a variety of methods, especially by impregnation with silver or mercury; yet the views with reference to their significance are exceedingly diverse. For a long time no one had ventured to doubt their nervous significance. And indeed most of the recent investigators also retain this view, (Rámon y Cajal, Anat. Anzieger, 1890; Fritsch, Akad. d. Wiss., Berlin, 1891); while Nansen, and especially Golgi and his school (Sala, Zeitschr f. wiss. Zool., 52 Bd.) deny their nervous significance, Kölliker (Zeits. f. wiss. Zool., 51 Bd.) and Waldeyer (D. med. wochenschr., 1891) consider that the matter is still undecided.

The protoplasmic processes pass out directly from the protoplasm of the cell body in such a way that weighty reasons had to be adduced in order to raise any doubt as to their nervous nature. These reasons were as follows: protoplasmic processes penetrate into regions which are especially poor in nerve fibres; and again they attach themselves by means of their ultimate ramifications to neuroglia cells and to the walls of blood-vessels, so that their function might be conceived as chiefly nutritive. Attention may be called to the fact, moreover, that even the facts upon which the views of the non-nervous nature of the protoplasmic processes are based cannot by any means be sustained by most other investigators.

A further question is whether the branchlets terminating the protoplasmic processes anastomose with neighboring cells; i. e. pass over directly into them. Appearances obtained by the method of silver impregnation seem to speak with the greatest distinctness against such connection. These terminal fibres may interlace so as to make a dense felt, but a direct connection seems to be excluded. Nevertheless, in the spinal cord of the electrical fishes at the point where the nerves for the electrical organs arise, Fritsch has observed very broad anastomoses between neighboring cells.

II. *The nerve fibre.* Several kinds of nerve fibres can be distinguished; but they all have one histological element, whose presence is the sole characteristic of nerve fibres and which is considered the only carrier of physiological energy—the axis-cylinder. We shall, therefore, limit ourselves to the consideration of the axis-cylinder and pass by the medullary sheath, sheath of Schwann, etc., since the first alone concerns the question of the inner relations of the nerve elements.

Touching the finer structure of the axis-cylinder, we have already seen, while speaking of the cell protoplasm, that the fibrillar theory and the theory of the hyaloplasm stand in opposition to each other. I might now add that Heitzmann (Jour. of Nerv. and Ment. Dis., 1890) regards the spongioplasm as contractile protoplasm and seeks for the material expression of nervous transmission in its varying contractions.

Our knowledge of the axis-cylinder has been materially broadened by Golgi, Rámon y Cajal, and Kölliker. These ininvestigators have shown that from the axis-cylinder of all longitudinal fibres of the spinal cord lateral twigs pass off almost at a right angle. There can be followed a greater or less distance into the gray substance and here they break up into a brush. It is, however, not improbable that all of the central nerve fibres send out "collaterals" of this sort, so that an isolated tract probably does not exist within the central nervous system.

III. *The terminal brush.* We have said that every nerve fibre, at the end opposite its origin from the cell, breaks up into the finest terminal branchlets, which are called the terminal brush. Such terminal brushes may radiate in the gray substance of the central nervous system; they may, however, also lie at the periphery of the body and here constitute the peripheral end-organ (sensory or motor apparatus). The termini of the motor nerves on the muscles, for instance, would belong to this category. We have thus a simple type of a neurone in the motor cells of the anterior horns of the spinal cord, together with the fibres of the anterior roots which spring from them, pass to the muscle, and here in the motor end plate break up into a terminal brush.

With reference to the peripheral sensory apparatus, a different relation seems possible. For many nerve fibres which serve the sensory functions we must assume that the cells from which the nerves originate (in this case not central ganglion cells, but peripheral sensory cells) are in the peripheral sense-organs ; e. g. the olfactory cells of the epithelium of Schneider's membrane, or perhaps the fibres arising from the rods and cones of the retina—in short, this relation seems to be the rule, or nearly so, for the nerves of the higher senses, the so-called nerves of special sense. But most sensory fibres, those especially which serve the sense of touch with its subordinates, pressure, temperature, and others, seem to end free at the periphery after they have here branched out into their terminal brushes.

Having spoken in detail of those structural units which together make up the whole nervous system—the nerve units, or neurones—and having seen that the most recent investigations furnish us with many new views with reference to them, we may proceed to discuss briefly how far our previous ideas of the structure of the nervous system must be modified in view of these facts.

First, I repeat that many of the more recent investigators proceed on the view that the neurones correspond throughout to the scheme previously explained ; i. e. that no nerve fibres pass directly into a nerve cell at both ends and that no ganglion cell has more than one axis-cylinder springing from it. Permit me, however, to state distinctly that neither of these positions seems to me conclusively proven.

In discussing the connection of every neurone with the rest of the nervous system, as well as with the organism as a whole, the question hinges on the relations of the terminal brush. Here three possibilities must be considered.

1. The terminal brush ends free at the periphery; e. g. at the motor end-plate of a muscular fibre.

2. The terminal brush enters into physiological connection with the nerve cell of a second neurone, or with the nerve cells of several other neurones.

3. The terminal brush enters into physiological connection with the terminal brush of another neurone, possibly with several neurones.

Although this is a matter of anatomical relations chiefly, yet I have always spoken expressly of physiological connection. We were a short time ago of the opinion that an unbroken fibre system was necessary for the transmission of nervous activities. The intercalation of nerve cells did not break the continuity, because in them the primitive fibrillæ did not come to an end, but merely suffered a change of position (M Schultze). Forel (Arch. f. Psych., 18 Bd.) and His (Abh. d. k. Sächs. Ges. d. Wissensch., 13 Bd.) were the first who showed distinctly that in order to render the transfer of the stimulus possible it is only necessary for the nervous elements to be contiguous, to lie adjacent to each other, or to intertwine. We formerly believed that actual anastomosis between the processes of the functionally connected nerve cells was indispensable. The proof of such gross anastomoses, however, was not possible (except in certain special cases; e. g. in the spinal cord of electrical fishes —Fritsch), and to trace out the finest anastomoses in the confusion of the ultimate ramifications would be regarded impracticable a priori. Successful silver or sublimate preparations, which render the finest ramifications clearly visible, also militate against the presence of anastomoses. Again, Kölliker and Rámon y Cajal observed that terminal ramifications of the nerve-felt, as extremely delicate, varicose fibrils, entwine the nerve cells and end on their free surface, often with fine tubercles. In a similar way the fibrils of the spiral fibres twine around the sympathetic cells (Ehrlich), as can be clearly seen after staining intra vivam with methyl blue. Hence, although we were before obliged to assume a continuity of the elements for the uninterrupted propagation of the nervous excitation, now we may no longer utterly reject the view that possibly even their contiguity may have the same functional significance.

By reason of the association of the nerve units arise those intricate tracts, the unravelling of which has so occupied anatomists in recent years.

We cannot possibly expect to call attention here to even the more important results which have been established with greater or less certainty. The few instances which follow may serve rather as illustrative of that which has preceded. They will show to a certain extent the practical applications of the views previously discussed. I select as the simplest illustration the psychomotor tract (pyramidal tract); i. e. that group of nervous elements which must be called into play when a voluntary muscular fibre contracts in response to an act of consciousness. We need for this purpose only two neurones. The first has its nerve cell in the cortex and from it the nerve fibre passes through the inner capsule, the pes pedunculi, the pyramids, and the pyramidal decussation in the cord. Here, in the appropriate place in the gray substance of the anterior horn, it forms a terminal brush. This is applied to the nerve cell of the second neurone, the cell of the anterior horn, from which the fibres of the anterior root arise, pass to the muscular fibre, and here subdivide in the motor end plate.

Kölliker, moreover, indicates that the few lateral twigs which branch off from the axis-cylinder process of the cells of the anterior horn also become fibres of the anterior roots, so that in this way several fibres take their origin from a single cell.

We must concern ourselves somewhat more minutely with the fibres of the posterior roots, since Golgi, Rámon y Cajal, Kölliker, and others have discovered new facts about their relations.

The fibres of the posterior roots arise, for the most part at least, from the ganglion cells of the spinal ganglia, penetrate into the cord and, after continuing some distance at right angles to the surface of the cord, divide into ascending and descending branches. These longitudinal branches constitute the principal part of the white posterior bundles, giving off, however, at right angles a number of collaterals which now for the first time penetrate the gray substance and there in various places break up into terminal brushes. Some of these terminal brushes surround the cells of Clarke's columns, from which again arise the fibres of the lateral cerebellar tracts; many collaterals of the fibres of the posterior roots pass through into the anterior horns here to subdivide; still others cross the middle line in the posterior commissure, etc.

Lenhossèk (Anat. Anz., 1800) and Rámon y Cajal describe also fibres of the posterior roots which spring from lateral cells of the anterior horn and, accordingly, merely pass through the spinal ganglion without coming into direct connection with its cells. Whether these fibres, which Edinger, Waldeyer, and others follow from the posterior horn through the anterior commissure into the decussating anterior bundles, are direct processes of the posterior roots or their collaterals, cannot be definitely decided.

When we inquire for the physiological application of the newly acquired anatomical knowledge of the spiral cord, we must first admit that it teaches us very little about the path of conscious sensations. Apparently the ascending longitudinal branches of the fibres of the posterior roots, for the most part, pass on into the medulla oblongata and here enter into physiological connection with certain cells (e. g. nucleus gracilis and nucleus cuneatus) which then by means of their axis-cylinder processes (as, for example, in the fillet) effect the connection with the cerebrum.

The simplest reflex loop is from the terminal brush of a sensory collateral in the anterior horn to a motor cell, from the latter of which the fibre of the motor root springs. The basis for more extended reflexes may be found in the fact that every longitudinal sensory fibre of the spinal cord sends a great number of collaterals into the gray substance of the cord.

With reference to the other parts of the central nervous system, especially the cortex of the cerebrum and of the cerebellum, the investigations of recent years has furnished an abundance of new knowledge. We cannot, however, enter into the subject here without widely trangressing our limits.

It was our purpose in writing these lines to give merely a general account and criticism of the most recent results in this field and to make plain how much our anatomical and physio logcal funidamental ideas must be modified by reason of them.

NEUROLOGISTS AND NEUROLOGICAL LABORATORIES.—No. 1. Professor Gustav Fritsch.

With Portrait.

Nothing is better calculated to impress the American student with the wonderful progress which the science of neurology has made during the last twenty years than a visit to European laboratories where he will find the patriarchs of the science still in the thick of the conflict.

A little more than twenty years ago, when phrenology still occupied the field of brain localization and it required some courage to seriously argue a close connection between nervous excitement and mental phenomena, two comparatively young men began a series of experiments which are worthy to be described by the much abused term "epoch-making." One of the adventurers in an untried field was primarily a physiologist, the other, whose journal of an extended African journey had already made his name familiar, was especially interested in anatomy.

As a result of these studies there appeared in 1870, in Reichert and Du Bois-Reymond's Archiv., a paper entitled "Ueber die elecktrische erregbarkeit des Grosshirns," in which it was for the first time demonstrated that electrical stimulation of definite areas of the front part of the cerebral cortex produces definite complex muscular contractions strictly limited to these areas. Such contractions appear in the muscles of the opposite side from that of the irritated hemisphere. Not less important was the discovery that other regions, to all appearance exactly similar, evoke no sort of muscular response under electrical stimulation.

Up to this time the science had remained under the ban of Florens' generalizations which, in spite of their great value, served to close the subject against farther experimental investigation.

Florens regarded the hemispheres as the seat of will and perception, but could find no evidence of division of labor. In whatever way he progressively removed the brain he was able to detect only a gradual sinking of the sum of the activities.

Now, however, as electrical investigation with greater skill and minuteness demonstrated the truth of variety of function in the cortex the way was open to resume the method of extirpation which had, since its partial failure in the hands of Florens, fallen into disrepute; and it was found that removal of those areas which under electrical stimulation evoked motor responses prevented any subsequent voluntary functioning of the muscles concerned. This observation has formed the point of departure for the fruitful labors of Goltz, Munk, Ferrier, Luciani, Seppilli, Gotsch, Horsely, and a host of others whose efforts have resulted in the enormous literature of our science.

The subject of our notice, Professor Gustav Fritsch, was born in 1838. After passing through the laborious years required to complete a course in Gymnasium and University, Dr. Fritsch, like so many of his famous contemporaries, sought to extend his scientific experience by explorations in the new fields recently opened. During the sixties he spent three years in South Africa in collecting materials which have since been elaborated in a number of scientific and popular works, and have formed the basis of the familiar lectures, illustrated with lantern slides, with which Professor Fritsch occasionally gracefully entertains a party of friends.

The results of the expedition so far as they relate to general anthropology, zoology and botany, were published under the title "Drei Jahre in Süd-Africa," (Breslau, 1868.), which also contains the itinery and incidents of the journey. In 1872 there appeared Die Eingeborene Süd-Afrikas, (Breslau), which gives a complete account of the native races of South Africa, and colored plates illustrating the peculiarities of color, and an atlas of sixty portraits. A popular description of South Africa appeared in "Das Winen der Gegenwart," Band 34, (Leipzig, 1885.), entitled Süd-Africa bis zum Zambesi.

The title of the inaugural dissertation, De medullare spinalio textura; Berlin, 1862, in which the prevailing views of that time were summarized, indicated the direction in which the African traveler was to find his permanent work. In 1875 there appeared a magnificent folio, published with the coöperation of the Berlin Academy of Sciences, entitled "Untersuchungen über den feineren Bau des Fischgehirn.'

In this work, the plates of which have not been surpassed for elegance and accuracy, a vast number of details, especially with reference to the fibre tracts, are recorded. When it is considered that serial sections were cut and mounted without recourse to the adhesive fluids and modern staining reagents, these results afford another evidence of the patience and skill of this veteran neurologist. The views advanced respecting the homologies of the several segments of the brain, were urged with much cogency and have long been defended. That some of these yield to a more extensive application of the comparative method and better technique, is no discredit to the author, than whom no one will welcome more eagerly all genuine advance.

After the death of the lamented Dr. Sachs, who had collected a large amount of material in South America, the task of editing the numerous notes toward a monograph of the electric eel, fell upon Professor E. Du Bois Reymond and at his instance Professor Fritsch undertook an independent investigation of the neuro-anatomy of this interesting animal. This study resulted in two papers entitled "Das Gehirn und Rückenmark von Gymnotus electricus," and "Vergleichend-anatomische Betrachtung der electrischen Organe von Gymnotus electricus," which form apendix I and II of Dr. Sachs' "Untersuchungen am Zitteraal."

This more or less accidental diversion has led to the production of a generous series of investigations on the anatomy of the electrical fishes in general. The first paper above mentioned was the first accurate description of the spinal cord and large electrical cells of Gymnotus, which, however, had been cursorally examined by Max Schulze; the second paper proposed the theory that electrical organs are simply modified muscles.

The first part of the elaborate monograph so well known under the title "Die Electrischen Fische," appeared in 1886, and was occupied with a description of Malopterurus electricus, in which the origin of the electrical axis-cylinders from the fusion of protoplasmic processes of the cells was described. The second part, 1890, was devoted to the Torpedo Group, from a systematic as well as neurological point of view.

The last number of this series "Weitere Beiträge zur Kenntniss der schwach elektrischen Fische," appeared in 1891, in the *Sitzungbericht d. Akad. d. Wissenschaft zu Berlin.* Among the interesting points are the discovery of large electric ganglion cells in the cord connected by extensive anastomosis, and the fact that the nerves form a chiasm dorsad and ventrad of the cord.

Among other papers of interest to neurologists is one which appeared in Archiv. f. mikr. Anat., describing remarkable giant cells lying outside the medulla of *Lophius piscatorius* and giving rise to enormous fibres connected. with the roots of the fifth nerve. The body of the cells is frequently perforated by capillaries. "Zur Organization von *Gymnarchus niloticus. Sitzb. Berlin Akad.* 1885," also "Ueber Bau und Bedeutung der seitencanäle unter der Haut der Selachier," loc. cit. 1886.

Professer Fritsch controls the microscopical department of the Physiological Institute of Berlin and himself lectures upon Normal Histology, Medical Zoology, Helminthology, Comparative Anatomy, Doctrine of Descent, etc., and conducts courses in Photographic Technique and Histology, in both of which he is ably assisted by Dr. Benda, who is one the ablest histologists in Berlin and a most finished gentleman and charming companion. Prof. Fritsch's laboratory is very largely used by American students, who frequently outnumber the German students. Dr. Benda's special courses in Technique prove specially attractive to medical students. The writer will not soon forget an accidental meeting with Professors Fritsch and Hitzig, both of whom are splendid specimens of physical development and of German culture at its best. Those who have enjoyed the hospitality of the subject of our sketch, cannot fail to be impressed with the many-sidedness and versatility of one who is not less an illustration of the minute specialism which we associate with German scholarship. The following supplementary list will serve to indicate how wide a range of subjects have been enriched by contributions from our author:

Die Parasiten des Zitterwelses. *Zitzungsber d. Akad. d. Wissensch. zu Berlin,* 1886. Zur Anatomie der Bilharzia hæmatobia. *Arch. f. mikrosk. Anat.* 1886. Zur vergleichenden Anatomie der Amphibien herzen. *Arch. f. Anat. u. Phys.* 1869. Das. Insektenleben Südafrikas. *Berliner entomologische Zeitschrift* Bd. XI. Das menschliche Haar als Rasenmerkmal.

Verhandl d. Berliner Gesellsch. f. Anthropologie, in *Zeitsch f. Ethnol. Anthrop. u. Urgeschicte*, 1885.

Die Lehre von der Einheit der amerikanischen Eingeborenenrassen untersucht an der Haarbeschaffenheit. *Verhandl. des Amerikanisten Congress*, Berlin, 1888.

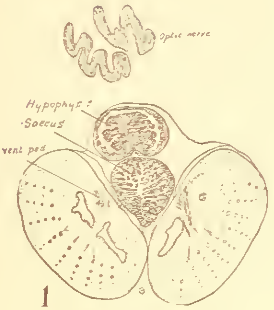
Also a large number of anthropological papers in Zeitschrift f. Ethnologie Anthrop. und Urgeschicte, besides geographical papers in Zeitschrift f. Erdkunde, and contributions to scientific photography in numerous special journals.

EDITOR'S' NOTICE.

As previously indicated, protracted absence in Europe has delayed the present number considerably and will also account for a number of unfortunate omissions and errors in the special February fascicle, The issue of this number has also been delayed by reason of the unaccountable miscarriage of an article by Dr. R. Burchardt, of Berlin, and other promised matter from abroad. This fact must be the editor's excuse for holding over manuscript now on hand, as the issue can be no longer delayed.

The February fasciculus was published cotemporaneously in the Bulletin of Denison University, which should have been noticed on the title page. Acknowledgement is here made to Prof. W. G. Tight for courtesies connected with the joint issue.

Journal of Comparative Neurology, Vol. II, PLATE IV.



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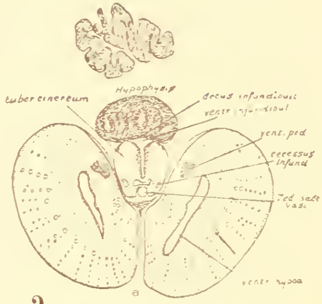

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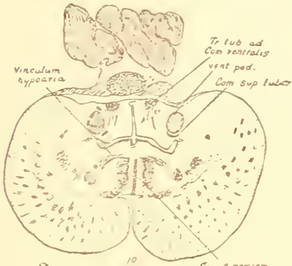

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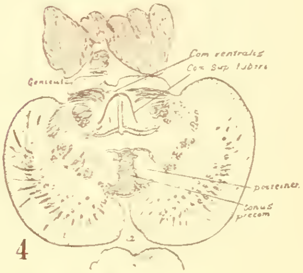

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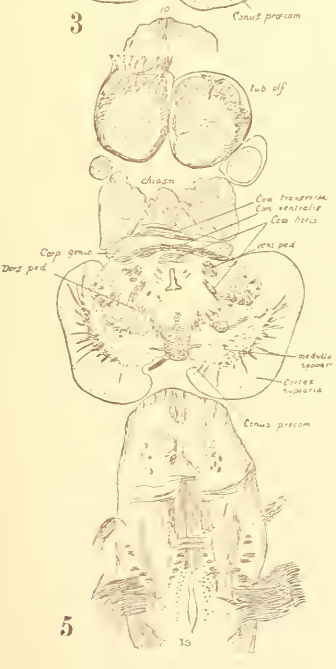

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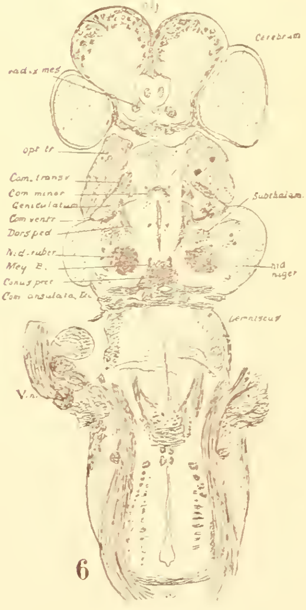

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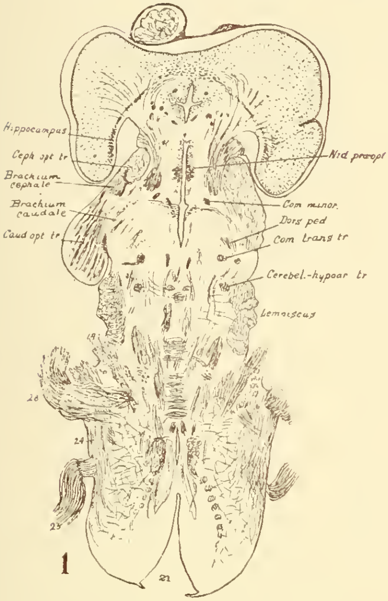
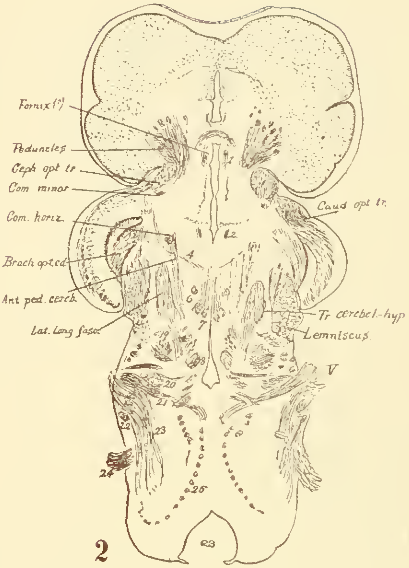

Hippocampus
Ceph opt tr
Brachium cephale
Brachium caudale
Caud opt tr
Nid preopt
Com minor.
Dors ped
Com trans tr
Cerebel.-hypoar tr
Lemniscus
19
26
24
25
21

1


Fornix (?)
Peduncles
Ceph opt tr
Com minor
Com. horiz.
Brach opt.cd.
Ant ped. cereb.
Lat. Long fasc.
Caud opt tr.
Tr cerebel.-hyp
Lemniscus.
V
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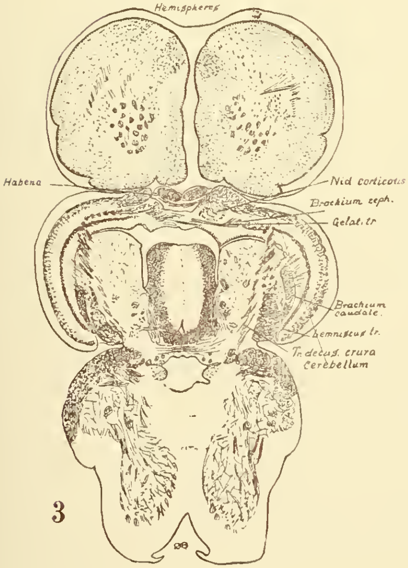
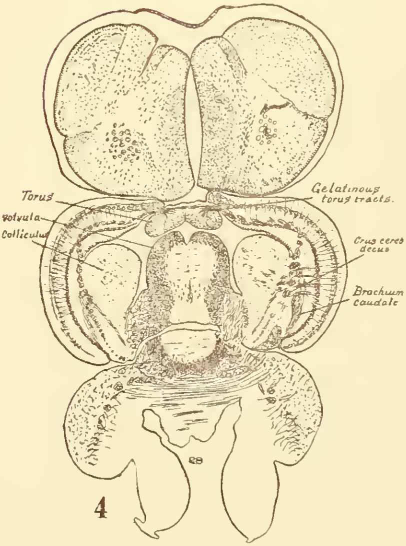
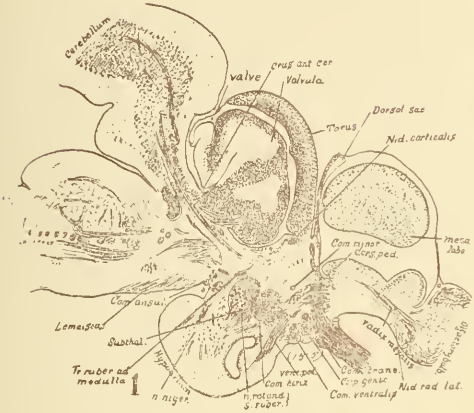
2


Hemispheres
Habena
Nid corticous
Brachium ceph.
Gelat. tr
Brachium caudale.
Lemniscus tr.
Tr. decus. crura
Cerebellum
28

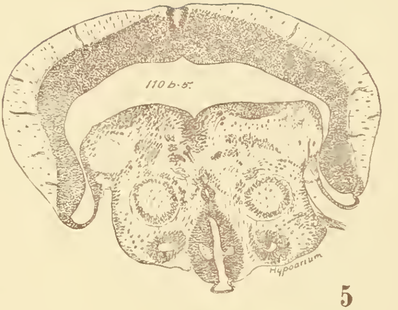
3


Torus
Volvula
Colliculus
Gelatinous torus tracts.
Crus cereb decus
Brachium caudale
28

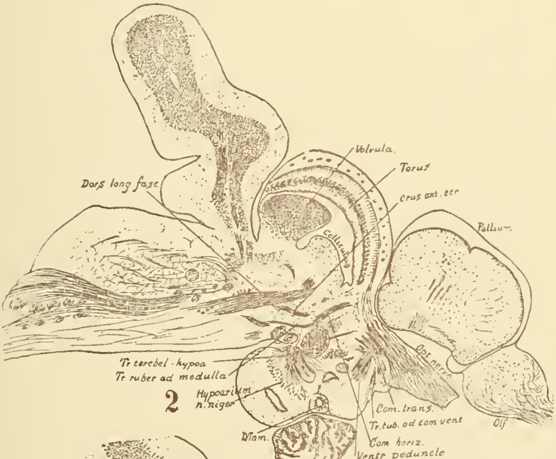
4


Cerebellum
valve
Crus ant cer
Volvula
Dorsal sac
Torus
Nid. corticalis
mesa lobe
Com minor
Dors. ped.
Com ansul
Lemniscus
Subthal.
Tr ruber ad medulla
Hypoarium
n niger
n. rotund
S. ruber.
vent. ped.
Com horiz
15
Com. trans.
Corp genic
Com. ventralis
Nid rad lat.
radix mesalis
olfactory bulb

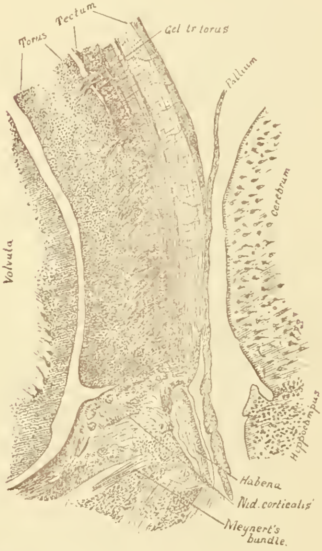
1


110 b·5.
Hypoarium

5


Volvula.
Torus
Dors long fasc
Crus ant. cer
Colliculus
Pallium
Opt nerve
Tr cerebel-hypoa
Tr ruber ad medulla
Hypoarium
n. niger
Mam.
Com. trans.
Tr. tub. ad com vent
Com horiz.
Ventr peduncle
Olf

2


Torus
Tectum
Gel tr torus
Pallium
Cerebrum
Volvula
Hippocampus
Habena
Nid. corticalis
Meynert's bundle.

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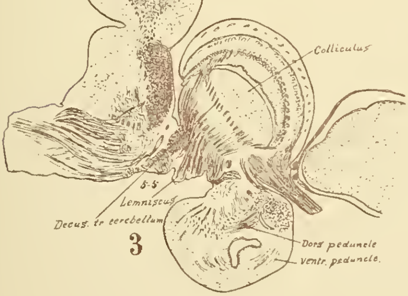
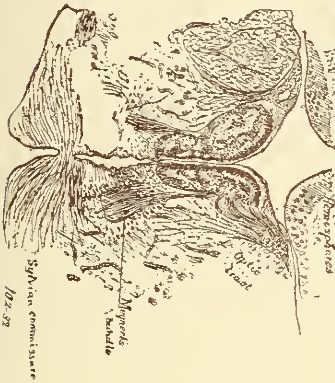

Colliculus
5-5
Lemniscus
Decus. tr cerebellum
Dors peduncle
Ventr. peduncle.

3


Tectum.
110-b
II a
Hypoaria
III

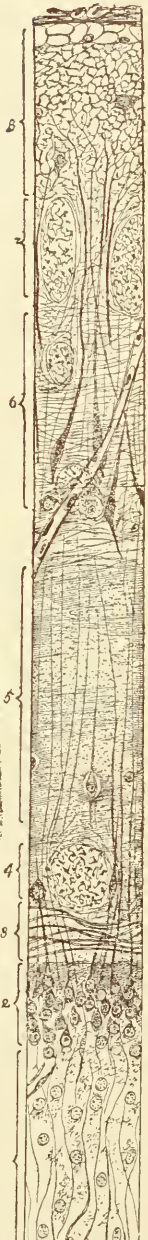
6


Sylvian commissure
102.37
Meynert's bundle
Optic tract
Hemispheres

6

5

4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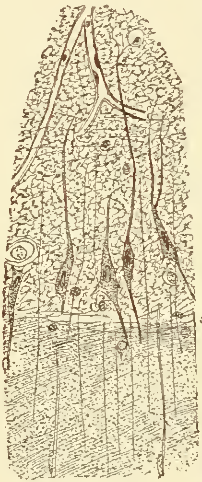

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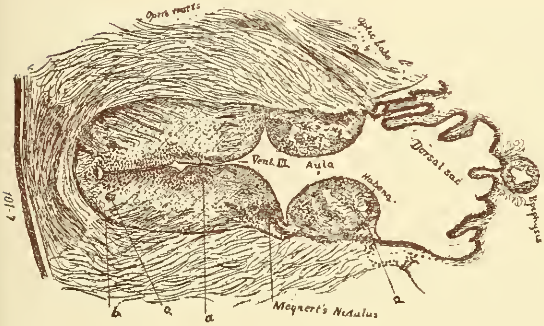
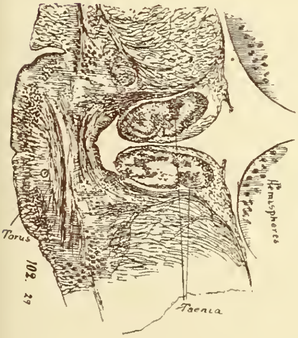

Optic tracts
Optic lobe
Vent. III
Aula
Habena.
Dorsal sac
Epiphysis
101.7
b
c
a
Meynert's Nidulus
d

7


Torus
102.29
Hemispheres
Taenia

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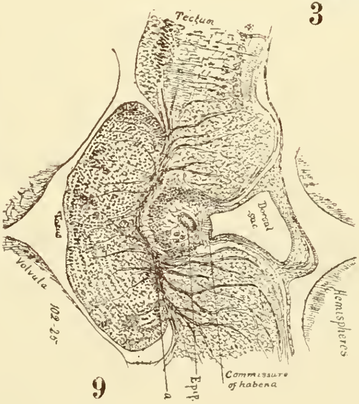
Tectum
Torus
Valvula
102.25
Dorsal sac
Hemispheres
a
Epip.
Commissure of habena

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110 (3)²

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110-3

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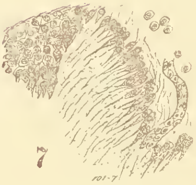
101-7

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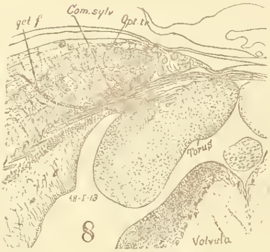
gel f
Com. sylv
Opt. tr
Torus
58-I-13
Volvula

8


Epiphysis
Optic. Lobe
Ventricle III
Mb
e
b
a
Com. tr
c
d
vent. pod
707-3.
Com vent

4


101-14

5a

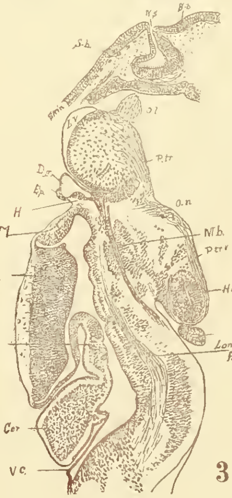
N.s
B.b
S.b
Smn
L.v
Ol
P.tr
D.s.
Ep
H
Tl
O.n
Mb.
Ptrr
To.
Hypo.
Vol
Long dors fasc.
Cer
V.c.

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PLATE IX.

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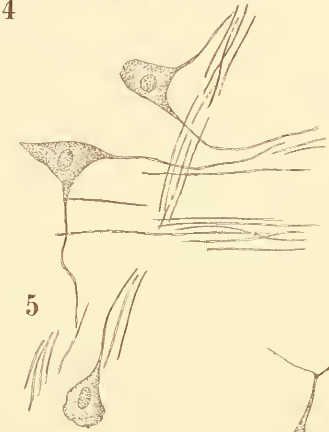

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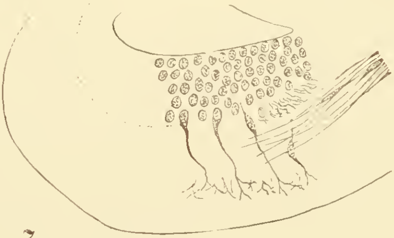

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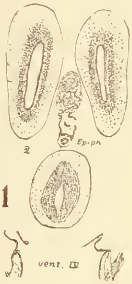

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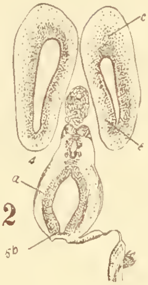

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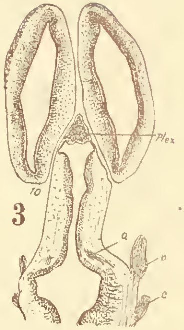

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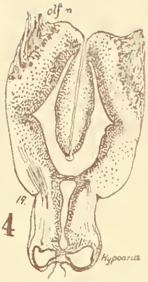

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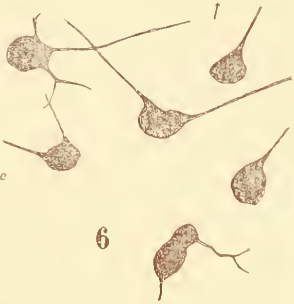

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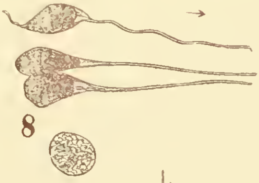

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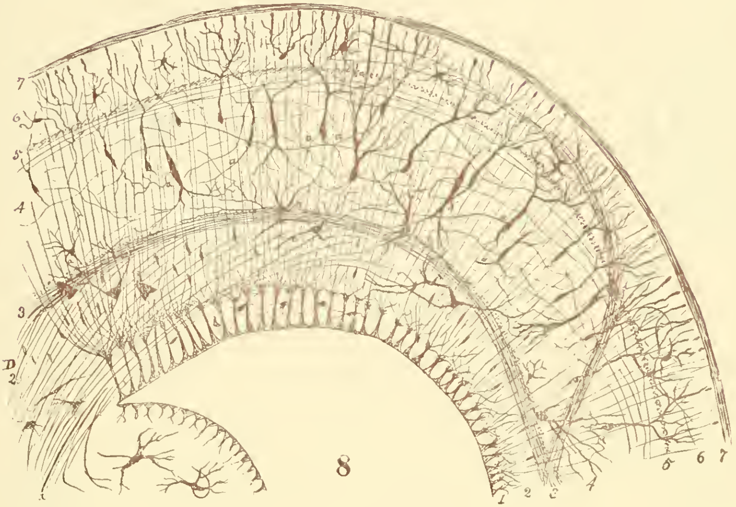

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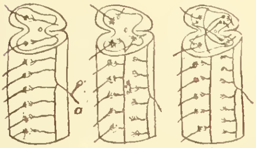

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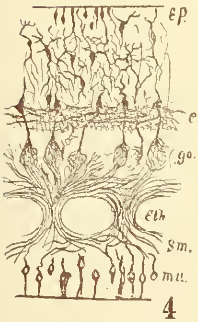

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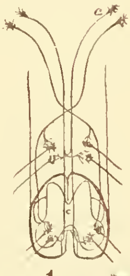

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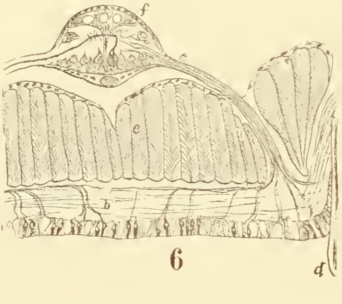

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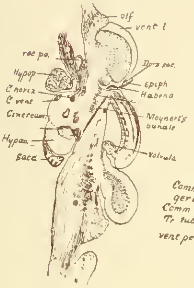
PLATE XII.



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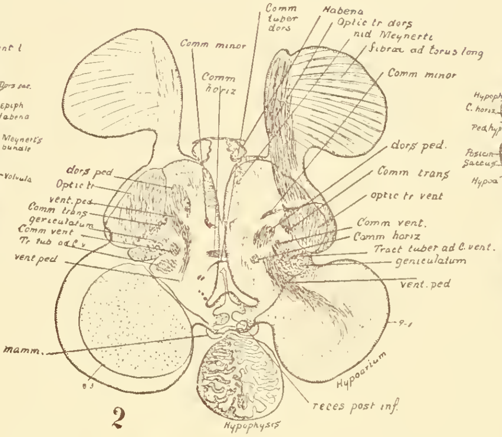

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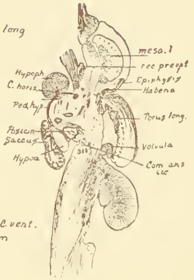

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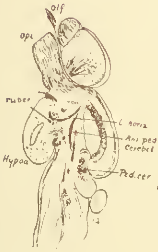

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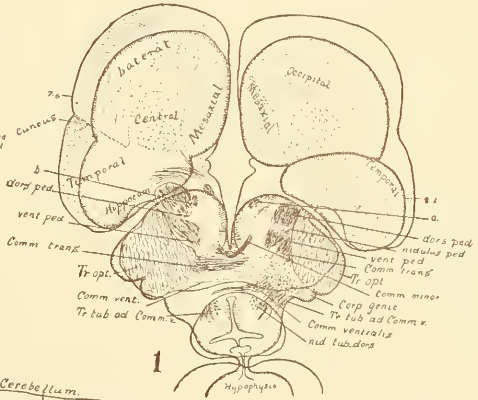

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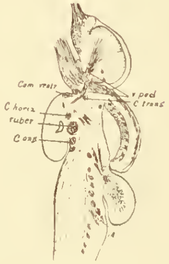

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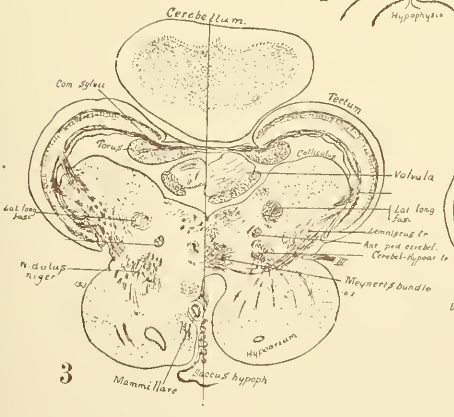

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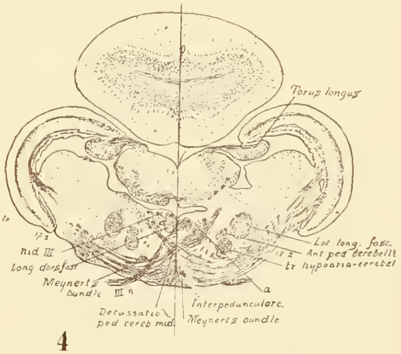

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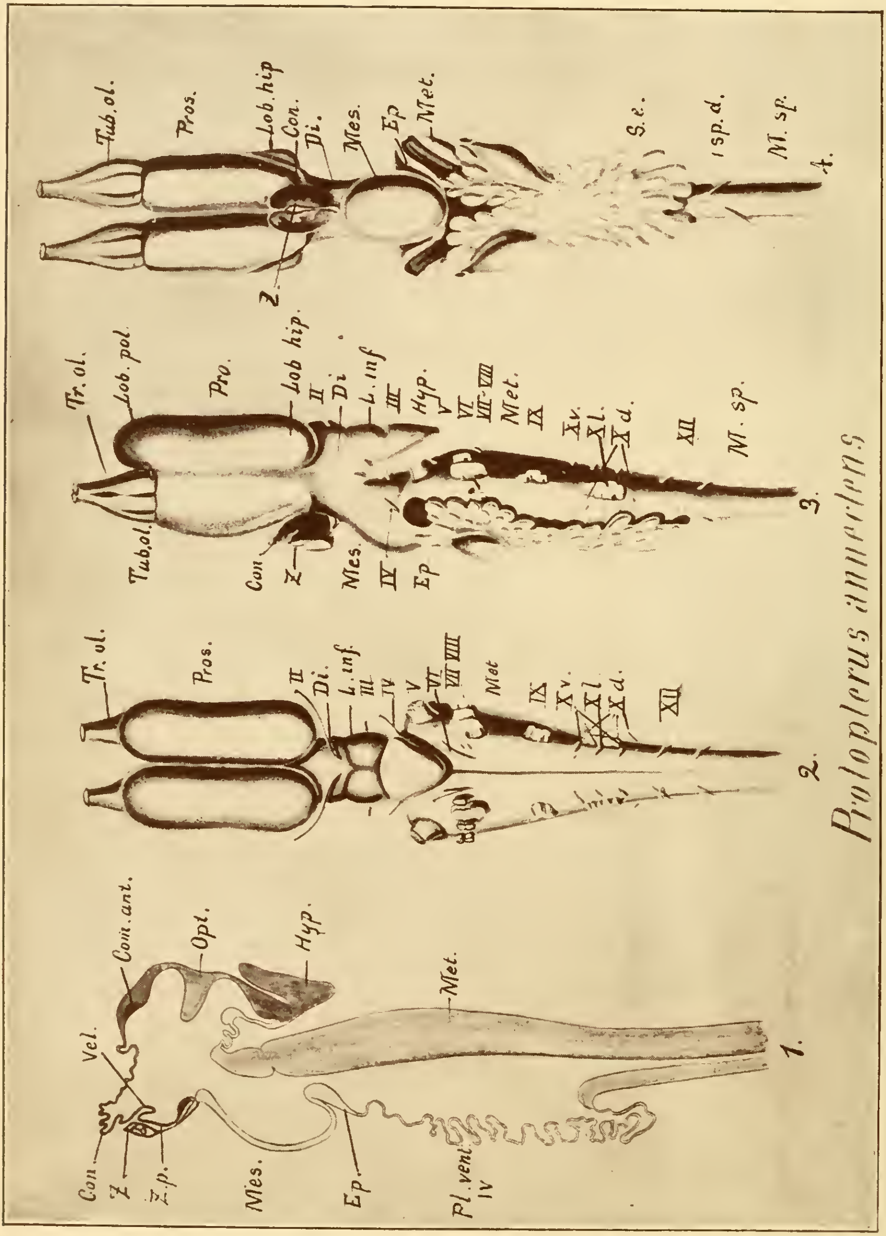

Protopterus annectens

THE CENTRAL NERVOUS SYSTEM OF PROTOPTERUS ANNECTENS.

Karl Rudolf Burckhardt, Ph.D., Assistant in the Laboratory of Anatomy, University of Berlin.

Of the former investigators, who have dealt with the central nervous system of *Protopterus annectens*, only one, namely, Füllignet, considers the microscopical anatomy. The work of this author is in many respects incomplete, especially as compared with the descriptions of the anatomy of other vertebrate brains. I have, therefore, ventured to subject it to another investigation.

The spinal cord shows the following structure: The disposition of the white and gray matter is as in Amphibia, in the anterior horn are found very large ganglion cells, the processes of which extend dorsad into the white substance, large cells are also found in the lateral portion of the gray substance. For the first time in the development of the animal kingdom, a substantia gelatinosa of Rolando is seen. Isolated neuroglia cells are found in the white substance, giving support to the fibres. The nerve roots pass out alternately, as has been often noticed in many of the lower vertebrates. A ligamentum denticulatum is found on each side of the cord.

The medulla oblongata is very simple in its structure and shows a slight flexure. From it are given off the following nerves:

1. The hypoglossal, with two ventral roots;
2. The vagus, with seventeen roots, of which three are ventral and fourteen are lateral;
3. The glossopharyngeal, with two large roots;
4. The fasiali-acusticus, with six roots;
5. The trigeminus with two roots.

The cerebellum is composed of a fold similar to the one found in the amphibia, though a little better developed. The nervi trochlearis and abducens, which have hitherto been unnoticed in the Dipnoi, were also found.

The mid-brain shows a layer of cells in the periphery, the axis cylinders of which pass into the opticus, otherwise its structure is very much as that of the mid-brain of Amphibia. The most important differences between the brain of Protopterus and that of the lower vertebrates is found in the primitive fore-brain. The roof of the diencephalon, which entirely escaped the notice of Füllignet (no doubt by reason of the imperfect conservation of his material) shows a complicated structure and forms a link between the amphibian brain and that of the Selachii. Just in front of the post-commissure is found the epiphysis with a structure like that described by Ehlers for the Selachii; its free end is attached to the frontal bones by means of the arachnoid, and at this point the cartilagenous skull shows a perforation. That portion described by Wiedersheim, Huxley and others as the epiphysis, is in reality composed of three parts, namely: 1, the "Zirbelpolster" of Edinger; 2, the velum, which represents a primitive form of the plexus choroideus medius; 3, the conarium (Adergeflechknoten of Goette), which may also be looked upon as showing a primitive condition. The lower surface of the diencephalon exhibits two small. yet always easily demonstrable lobi inferiores [hypoaria]. The hypophysis is composed of a glandular and nervous portion.

The fore brain shows exceptional development. There exists a posterior ventral portion, which according to its structure must be regarded as the lobus hippocampus. In it cells are found which correspond in form to those found in the fascia dentata of the mammalian brain; fibres which connect them with the lobi inferiores are also seen. In the entire pallium of the fore brain, there exists a layer of ganglion cells which have been separated from the central grey matter and lie in the white. Another thin layer, found only in the anterior part of the fore-brain, send fibres into the lobus [tuber ?] olfactorius. Contrary to the views of Füllignet I must state that a lobus olfactorius exists and is everywhere marked off from the other portions of the brain, by a fissure. The nervous trunk which leaves this lobe is, for a short distance, divided into a dorsal and a ventral portion, only to unite again before it reaches the olfactory membrane. Ventrad of the lobus olfactorius there is found a distinct elevation such as may be well seen in selachian brain; for it I suggest the name, lobus post-olfactorius [post-rhinal lobe of Herrick Ed.] The lobe is found in the Amphibian brain, but in a much reduced condition and correspond to what His describes as the lobus olfactorius posterior in the human embryo, forming the substantia perforata in the adult brain. The arachnoid is developed only in certain regions, in the region where the "adergeflecht" [plexus choroideus] is united to the bony skull, again near the epiphysis. Over the fourth ventricle a saccus endolymphaticus is found, which spreads itself widely over the roof, and in it otoliths have been found. This sac is not in communication with the central cavity of the spinal cord.

Taken in general, we may regard the brain of *Protopterus* as a link between the amphibian and selachian brain, especially when the fore- and mid-brain are considered. In a monograph on the central nervous system of *Protopterus annectens*, which is now in preparation, the observations here recorded will be more carefully and more fully detailed.

PLATE XIII.

Fig. 1. Median longitudinal section of the brain of Protopterus annectens. Enlarged five diameters.*

Fig. 2. Ventral view of the same. x2.

Fig. 3. View from the right side. x4.

Fig. 4. Dorsal view of same. x4.

i—x, cranial nerves, *v*, *l*, *d*, ventral, lateral and dorsal roots respectively; *Com. ant.* præcommissura; *Con.* conarium; *Di.* diencephalon; *Ep.* epencephalon; *Hyp.* hypophysis; *L. inf.* lobi inferiores; *Lob. hyp.* lobi hippocampi; *Lob. pol.* lobus postolfactorius [postrhinalis]; *M. sp.* medulla spinalis; *Mes.* mesencephalon; *Met.* metencephalon; *Opt.* optic nerve; *Pros.* prosencephalon; *Pl. vent. IV.* metaplexus; *Tr. ol.* tractus olfactorius; *Tub. ol.* tuberculum olfactorium; *Z.* epiphysis.

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*During reproduction this plate has been somewhat reduced.

ON THE HISTOLOGICAL STRUCTURE OF THE MEDULLA OF PETROMYZON.

J. David, Ph.D., Berlin.

In the course of my investigations with the new methods of Golgi and the modification used by Ramon y Cajal, on the central nervous system of various vertebrates, I found that the nerve fibres in the brain and the spinal cord of Petromyzon stained especially well.

Nansen,[1] in his investigations upon the central nervous system of vertebrates, makes mention of the structure of the medulla of Myxine glutinosa; he demonstrated with the silver method multipolar cells possessing one nervous and several, three or four, protoplasmic processes, the latter extending toward the surface and ending in little enlargements. The nervous processes belong to both types described by Golgi.

This method however is in Petromyzon more valuable in the results it gives in the way of showing the course and distribution of the nerve fibres, which are stained much more clearly than the body of the cells. The few of these latter I saw in P. fluviatilis, are found on each side of the central canal, near the median line, they seemed more numerous in the anterior part of the medulla, Fig. 1 and 2. These cells have been described by *Reissner* (Müller's Archiv. p. 545), *Ahlborn* (Zeitschr. f. wiss. Zool. 1883); also by *Retzius*, in his Biologische Untersuchungen, II Folge, 1891. The latter author used the methyl blue method of *Ehrlich* and obtained good results upon cells and fibres. He gives also one cut showing the results of the *Golgi* method in Myxine.

The processes of these cells pass into the fasciculi longitudinales into the ventral nerve roots, and also into the white commissure. The protoplasmic processes pass into the superior, lateral and inferior part, and penetrate also into the white substance. The indistinct separation of the grey and white matter, as also the

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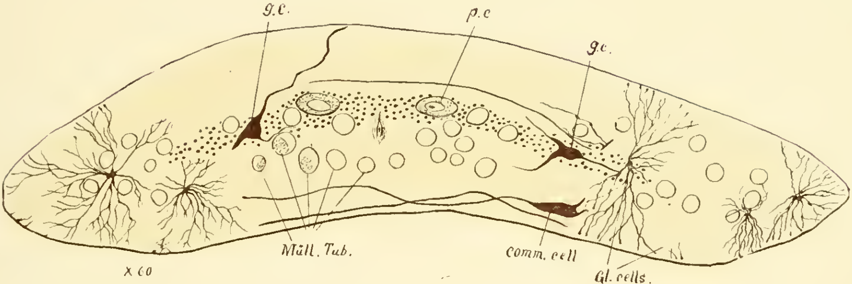
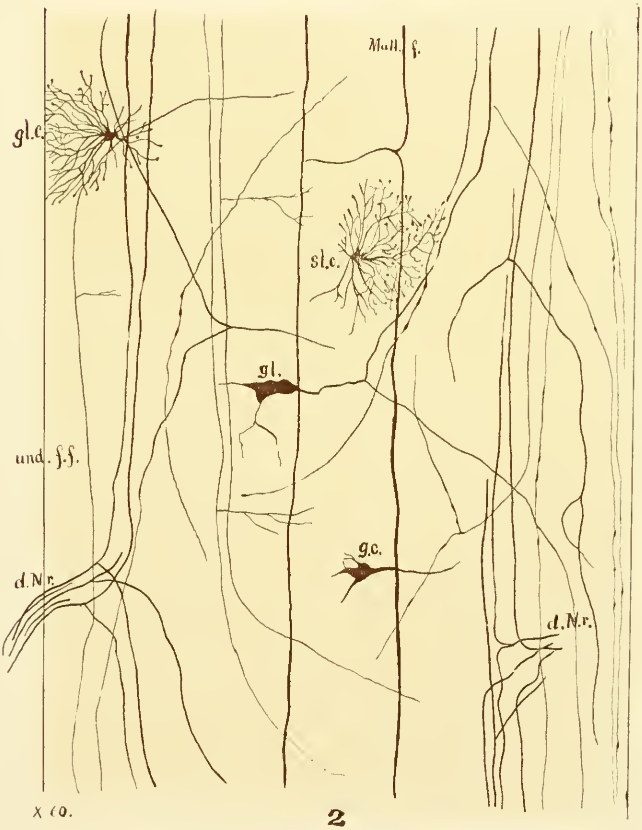
[1] Bergens Museums Aarsbereting, 1886.


g.c.
p.c
g.c.
Müll. Tub.
comm. cell
Gl. cells.
× 60

1


ax. cyl

3


Mull. f.
gl.c.
sl.c.
gl.
und. f.f.
g.c.
d.Nr.
d.N.r.
× 60.

2

shortness of the processes may be looked upon as an embryonic condition, characterized by the slight differentiation of the nervous elements, while the absence of cornua anterior and posterior seems to be a consequence of the flatness of the medulla.

The course of the fibres is very clearly followed. As is well known, the spinal medulla is flat and thin. Short pieces, 1 cm. in length, were placed in the hardening fluid for about a week,[1] into silver Nitrate two or three days, and then cleared in Origanum or Dianthus oil, until they were transparent. In this way beautiful preparations were obtained and the deeply stained axis cylinders could be well followed. The thicker ones near the central canal (fibres of Müller) have a straight course, the finer ones near the periphery a more undulating one. (See Fig. 2.)

These fibres could be followed through several of the 1 cm. long segments, which I placed in the solution. With certainty I was able to trace only the Müller's fibres to their ending in the acusticus and trigeminus nuclei. Transverse sections (Fig. 1) show that the fibres of Müller are imbedded in tubes of the glial substance.

In their whole course they give off collateral branches, which end above and below in the grey and white substance, they often divide dichotomously and end in fine, irregular branches, often bending back into the grey matter, (Fig. 2). They may take their origin in the cells, as above mentioned, or from the dichotomous branching of the posterior roots, which divide in the form of a T or Y, one branch passing forward and the other backward.

I never saw one of these "root branches" end in a cell, but as above stated, the cells were not always well stained and it may be only a result of the deficiency of the method.

One sees no special arrangement of the elements in the grey matter as in higher vertebrates, the distribution of cells and fibres is very simple and seems to represent an embryonic stage.

I am very sorry to state that I was not able to determine

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[1] With good results we added to the three per cent. bichromate of potash solution crystals of the same salt; these dissolve slowly and concentrate the fluid.

the ending of the fibres of Müller, any more clearly than *Ahlborn* could with the carmin method. I tried to combine the *Golgi* and the carmin methods, with no better results. The fibres stained very clearly, the cells how ever remained unstained. The fresh material at my disposal was so limited that no modifications of the methods could be tried.

The transverse fibres which *Retzius* stained in Myine glutinosa with methyl blue, were not at all impregnated in my preparations.

The *glia cells* are found quite frequently in the grey and in the white matter. They possess a small cell body, with granular protoplasm and a corona of fine processes going off from every side. Their size varies very much. I mistrust that many of them were interpreted as nerve cells by *Reissner* and *Ahlborn.*

These authors made three (*Reissner*) and four (*Ahlborn*) layers of proper nerve cells and find them most numerous about the central canal and in the lateral parts just where the glia cells above described are also found. I would suggest that these cells may be looked upon as undifferentiated intermediate ones, between the glia and fully developed nerve cells.

The processes of these "arachnoidal cells" end in small nodules, passing upward and downward to the periphery of the spinal cord. also uniting both surfaces together, a relation which is not found in any other vertebrate. so far as I know.

PLATE XIV.

In the figures I combined the most characteristic features from several preparations, but tried, however, not to embrace more in one drawing than is usually seen in a good preparation.

Fig. 1. Transverse section of Petromyzon fluv. medulla.

pc. Posterior cells of Freud, (remain unimpregnated;) *gc.* Ganglion cell; *cc.* Commissural cell; *Mull. T.* Tubes of the Mullerian fibres, some of them containing the fibres; *Glc.* Glia cells, the two layers.

Fig. 2. Dorsal view of an impregnated and cleared segment of spinal cord.

d. n. r. Entering dorsal nerve rod, showing T and Y branching fibres; *Mull. f.* Mullerian fibres, straight course; *und. f.f.* Undulating fine fibres withcol lateral branches.

Fig. 3. Typical ganglion cell with three protoplasmic processes.

PSCYHOLOGICAL NOTES UPON THE GALLERY SPIDER —ILLUSTRATIONS OF INTELLIGENT VARIATIONS IN THE CONSTRUCTION OF THE WEB.

By C. H. Turner.

At the suggestion of Professor C. L. Herrick, a great many observations have been made upon the morphology of the gallery webs. A partial summary ot the results of that study is given in this paper.

To facilitate description the different parts of the web have been named. The main expanse of the web has been called the main sheet. Ascending from the outer edge there is often a more or less vertical portion. This has been called the guard sheet The loose network of threads above the main sheet constitutes the snares. The name gallery has been retained for the hiding place of the spider.

In the meadows, the web of the gallery spider is an irregular sheet, stretched from blade to blade of grass. There is no general pattern to which they all conform. Not only the shape of the web, but also the number of sides and proportions are subject to great variation. The aim of the spider seems to be to cover as much ground as possible. The gallery is usually located at one extremity of the web; but sometimes it penetrates the main sheet from below and near its centre. If there is a crack in the ground at that place, the gallery is usually located in it. Occasionally the gallery is concealed beneath a stick or leaf, but often it is merely hidden in the grass. Numerous observations have been made upon these meadow webs; but the conditions are too uniform to yield much of psychological value. But when the external environment becomes more heterogenous, it is interesting to note how the spiders become masters of the situation.

Example I.—Location: bottom lands bordering on a creek.

Main sheet large, horizontal, irregular in outline, attached to two logs and to the tops of several weeds.

Gallery located in one end. Guard sheet absent.

The above might be taken as a general type of the irregular web. But the following observations made in the same locality, upon the same species, at the same will illustrate how the spider adjusts its web to slight changes in the environment.

EXAMPLE II.—Location: bottom lands bordering on a creek.

Main sheet large, horizontal, irregular in outline, attached to two logs and to the tops of several weeds. In the midst of this sheet a branching weed was growing. The branches of the weed pierced the web in several places. In all cases the web was intimately connected to these branches. Gallery in one end. Guard web absent.

In the following case, the spider has certainly become master of the situation.

EXAMPLE III.—Location: stone wall, above a hole and beneath a projecting ledge.

Main sheet irregular in outline, intimately attached to the wall, extending as a horizontal bridge from stone ledge to stone ledge across a wide hole. Gallery in the back part of the web, about half way between the two extremes. Guard sheet very high, extending along the whole outer edge of the web and attached to a stone which roofs the web. Snares few, extending from inner edge of web to the stone roof.

This device is a most effectual insect trap. No doubt insects resting or walking on either ledge often attempt to pass through this trap to the ledge beyond. Once inside of the structure, there is no escape. The insect cannot escape to the right, because the wall is there; it cannot escape to the left, because the guard sheet is there; it cannot escape above, because the stone roof is there; it cannot escape celow, because the main sheet is there. But it must continue along the broad way that leads to destruction. Sooner or later it impinges against a snare, falls upon the web, and is captured by the expectant spider. Was this web the result of blind instinct? I think not. It must not be supposed that all of these irregular webs are horizontal. Usually they are so, but often they are more or less inclined. The following observation is an illustration.

EXAMPLE IV.—Location: a railroad embankment, covered with large cinders and weeds. Main sheet irregular, inclined, extending from a large cinder upwards to several weeds Gallery near one of the corners, penetrating the main sheet from below. Guard web absent.

The main sheets of all the webs so far considered are irregular in outline. This is not always the case. The main sheets of many webs have definite outlines, the outlines being determined by the environment. The triangular web is the commonest form. These are found in corners everywhere.

These triangular webs are sometimes horizontal, sometimes inclined toward the apex, sometimes inclined toward the foot. The following examples may serve as types of many..

EXAMPLE V. Location: angle between stone wall and wooden post. Main sheet horizontal, attached in the angle between the wall and post. Gallery in the angle. Guard web practically absent. Snares few.

EXAMPLE VI.—Location: angle between two logs. Main sheet inclined, passing from the apex of the angle upwards and outwards at an angle of about five degrees. Gallery at the apex of the triangle at the lowest point of the web. Guard web absent. Snares abundant.

EXAMPLE VII.—Location: angle between window-sill and side wall. Main sheet attached in the angle between the projecting window sill and the side wall. The sheet slopes gradually downward along the side wall. Gallery in the angle. Guard web, highest at the lowest point of the web. Snares abundant.

These I have called types. But the introduction of a new element in the environment is sure to call forth a modification to meet the case at hand. For example, if a ledge be near, a portion of the web is almost certain to be extended along that ledge for a short distance.

The two following adaptations are further illustrations of the same thought.

EXAMPLE VIII.—Location: angle between window-sill and side wall. Main sheet horizontal, attached to the window and to the side wall. Above this web there was a web of another spider of the same species. A tension string united the main sheet of the web under consideration to the main sheet of the web above it. Gallery in angle. Guard web present, the same height everywhere. Snares abundant.

EXAMPLE IX.—Location: angle between window sill and side wall. Main sheet stretched from window sill to the side wall. The sheet inclined, the side next to the window being the lowest. Gallery in the angle. Guard sheet high, especially so near the window. It would be difficult to find a more effective device than this for capturing flies that come gliding down the window-pane.

The observations recorded in examples VII, VIII, and IX were made upon the same species of spider, in the same locality and at the same time. This fact gives the observations great weight. It shows that, under similar circumstances, individuals of the same species occasionally arrange their webs quite differently. Professor Morgan says that "Instinctive actions are those which are performed by the individual *in common with all the members of the more or less restricted group*, in adaptation to certain oft-recurring circumstances" If instinct be no more than this, surely these spiders have transcended instinct.

Among these triangular webs I have met with another interesting modification.

EXAMPLE X.—Location: angle between a stone wall and a vertical post. Main sheet triangular, attached in the angle between the wall and post. Web nearly horizontal, bagging slightly in the centre. Gallery in crevice between wall and post. Snares few, attached to both wall and post.

The following is an extreme illustration of the same thing.

EXAMPLE XI.—Location: angle between two walls. Main sheet attached to both walls, in shape resembling an inverted Japanese hat with a triangular brim. Numerous small bits of whitewash were found in the depression. Gallery in the angle.

It is a noteworthy fact that in both these cases and in other similar ones, neighboring spiders of the same species had constructed webs that were approximately flat.

At first blush, example XI appears to give us an example of a spider deliberately constructing an incline down which struggling insects would roll to their doom. But I am not sure that such an interpretation is warranted. The bits of whitewash in the web are very suggestive. Why may not bits of whitewash falling into such a web as is described in example X, have such so stretched that web as to produce the one described in example XI. This possibility is strengthened by the following fact: By dropping bit after bit of wood into a web of the type described in experiment X, I was enabled to produce a web of the type described in example XI.

I have, however, seen a few webs where the funnel shape was something more than a transformation by stretching of an originally slightly bagging web. The following example is an illustration.

EXAMPLE XII.—Between two vertical and one horizontal log. Main sheet funnel shape, the apex of the funnel being vertical. Gallery vertical, at the apex of the funnel. Guard web absent. Snares very abundant, forming a loose horizontal network.

Next in number to the triangular webs come the rectangular webs. The rectangular webs vary in shape from perfect squares to very long rectangles. The sides are sometimes straight and sometimes curved. Occasionally more remarkable variations are encountered.

EXAMPLE XIII.—Location: crack in an old tree trunk. Main sheet nearly horizontal, attached on all sides to supports. A short distance above the main sheet there was a parallel secondary sheet. This sheet completely hid the gallery from above. This secondary sheet was nearly as large as the main sheet. Gallery at one corner in a crack. Guard well on one side only, high near the trunk. Snares abundant.

This secondary sheet is an interesting feature. Unfortunately I had no opportunity to see the inhabitant of this web. Therefore I cannot say whether it was an individual of the same species as the spiders of the neighboring webs or not. None of the other webs of that vicinity porsessed a secondary sheet above the main one.

As in triangular webs, so here the main sheet often departs a great deal from the horizontal. Among my notes is recorded one of these inclined webs which contains a noteworthy modification.

EXAMPLE XIV.—Location: ledge in stone wall in front of a hole in the wall. Main sheet extends from the ledge upwards, at an angle of fifteen degrees, to a lateral prolongation of the rock that forms the roof of the hole. Thus we have gradual incline, passing from a lower to a higher ledge. A portion of this sheet extends into the hole and forms a carpet in the same. Gallery hidden under the stone at the top of the incline. Guard web on the outer side very high, attached to the stones above the web. Snares absent.

This is a remarkable web. Those who run may read that it serves a double purpose. The high guard web insures the capture of insects that attempt to fly out of the hole; while to walking insects the gentle incline forms a tempting bridge by which to pass from ledge to ledge. Once on the web the spider claims them for his own. Note also that the position of the gallery is such as to render it invisible from either the hole or the ledge. Is this web the result of mere instinctive construction? I think not. Here an individual has built differently than the remaining individuals of the same species. Here again an individual has transcended instinct and entered the arena of intelligence.

The main sheets of all the webs so far considered are single. I have noticed five cases where the main sheet was compound. For the sake of completeness I give them all.

EXAMPLE XV.—Panel of door. Main sheet attached to side and back of panel. This sheet consists of two divisions. The first portion slants downward, at an angle of about fifteen degrees, along the back of the panel for quite a distance. Here the second division begins and passes upward at the same angle until it reaches the level at which the first division began. Gallery in the angle. Guard web high. Snares abundant.

EXAMPLE XVI.—Location: log pile. Main sheet stretched over the logs. It consists of two divisions. One half is nearly horizontal, the other slants upwards at quite an angle. Gallery piercing the centre of the web, from below. Guard web absent.

EXAMPLE XVII.—Location: log pile. Main sheet consists of two parts. One portion is horizontal and flat, and attached to two intersecting logs. The other portion resembles an inverted, triangular Japanese cap. This portion is continuous with the first division, but it is attached to weeds instead of logs.

Gallery horizontal, located in the angle between the logs. Guard sheet absent.

Here again we meet one of those basket-like webs. [cf. example XI.] In this case, however, the depression was empty.

EXAMPLE XVIII.—Location: weeds and logs, near the ground. Main sheet is horizontal and consists of three rectangles arranged like the lobes of a clover leaf. Gallery in a hole in a log. Guard web absent. Snares abundant.

EXAMPLE XIX.—Location: two adjacent vertical posts. Main sheet double. As the posts stood there were two angles between them. These angles were opposite each other. In each angle was located one division of the main sheet of the web. These two divisions were not counterparts of each other. Sheet number one was horizontal and attached to the two logs and a neighboring log. Sheet number two was inclined and was attached to the two logs and to neighboring weeds. Gallery common to the two webs, hour-glass shaped and located between the two logs.

With one exception, this appears to be the most remarkable web that I have ever encountered. It seems as though the builder had been animated by thought similar to those which prompts a school boy to fish with two lines instead of one. It seems as though the spider has learned to kill two birds with one stone. Among the piles where this web was found there were hundreds of webs. There were also numerous places where double webs of the above type might have been constructed. Yet the above example was the only one observed in that place. That spider appeared to be the master mind of the locality.

About the posts of ancient rail fences, I have occasionally thought that I observed other webs of the kind described in example XIX. But in no case was I certain of this.

Next to the main sheet, the gallery is the most conspicuous portion of the gallery webs. Like the main sheets, the gallery is subject to great variation. But usually these varations do not consist of changes in the form of the gallery. I have noticed one case where the gallery was hour-glass shape, [see Ex. XIX] but as a rule the gallery departs but little from the usual conical shape. The variations here are of a different sort. They consist in variations in the location of the gallery.

By far the most common position for the gallery is in some angle of the web, [see example X]. It is usually located in that angle which contains a crack or a hole or some foreign body within which or under which the gallery can be concealed. But this is not always the case. I have often seen the gallery in a corner which contained no contrivance which might be utilized as a shield for the web, when, at the same time, another corner of the web afforded ample facilities for such concealment.

When the web is inclined, the gallery is sometimes in the lowest portion of the web, as in example VI and sometimes in the highest portion of the web, as in the following example.

EXAMPLE XX.—Location: window-sill. Main sheet is inclined, highest at one place upon the wall, from which it slopes in three directions to the sill. Gallery at the highest point. To prevent the roof of the gallery from collapsing, tension lines extend from the top of the gallery, over the main sheet, to the sill. Guard web absent. Snares absent.

Although the gallery is usually situated in an angle, it is not always thus located. It is often appended to one of the sides of the web. Example III is an illustration. There the galleries situated half way between the two extremes of its web. In the shadow, half way between the two extremities of that treacherous bridge, the spider awaits its victim. Could man have selected for it a better station? I will cite one other example.

EXAMPLE XXI.—Location: angle between a stone wall and a wooden post. Main sheet triangular, attached in the angle between the wall and post. Gallery in a hole in the wall at about one third of the length of the web from the intersection of the wall with the post. It is a noteworthy fact that in this case there was a crack in the corner in which the gallery could have been constructed. Guard web quite high, highest near the wooden post. Snares very scarce

The following example is a more striking illustration of the same thing.

EXAMPLE XXII.—Location: angle between stone wall and wooden post. Main sheet triangular, horizontal, attached in the angle between the wall and the post. Gallery on the wooden post at quite a distance from the intersection of the stone wall and the post. In this case there is no hole in the post, but there was a crack between the post and the wall in which the gallery might have been hidden. Guard sheet practically absent.

The spider that constructed this web was a member of the same species as the spider that constructed the web recorded in example V. Here again we have an example of individuals of the same species, under similar circumstances. constructing dissimilar webs, and here again we have an example of something that transcends instinct.

We now come to consider variations in the morphology of the guard sheet. In some cases it is absent. In horizontal webs it is more often absent than present. According to my observation, in horizontal webs, the ratio of the times present to the times absent, is as one is to two. When the guard sheet is present in horizontal webs, it may be either low or high. Compare example III with the following.

EXAMPLE XXIII.—Location: rectangular space formed by water pipe, side of house and fence. Main sheet horizontal, rectangular attached to fence, house and pipe. Gallery behind the pipe. Guard web exceedingly low. Snares few.

Occasionally webs are encountered in which the guard sheet is present in some portions of the outer side while it is absent from others. The following observation is an illustration of this.

EXAMPLE XXIV.—Location: between stone wall and wooden post. Main sheet attached in the angle between the post and wall. The sheet is horizontal, bagging slightly in the center. Gallery in crevice between wall and post. A low guard web is present near each extremity of the exposed side of the web while the guard web is absent from the middle of that side. Snares few, attached to both wall and post.

Among inclined webs, the guard sheet is more often present than it is in horizontal webs. But even here the number of times the sheet is present predominates but little over the number of times that it is absent. Example IV, VI, XII and XX are illustrations of cases where the guard sheet is absent, although the web is inclined.

As in horizontal webs, so here, the guard sheet is sometimes high and sometimes low. Examples number VII, XXI and the following example are illustrations of a modification that is quite common.

EXAMPLE XXV.—Location: angle between brick-wall and water-pipe. Main sheet triangular, attached in the angle. Inclined, lowest where it joines the pipe. Guard web highest at the pipe, gradually diminishing in height as it approaches the brick wall. The following is an extreme case of the same sort.

EXAMPLE XXVI.—Location: angle between the book case and and the wall at level of the top of wainscoting. Main sheet inclined sloping at an angle of 45 degrees from the top of the wainscoting up to the book case. Guard web present only at the lower extremity of the web. There it forms a low fence along the outside of the wainscoting. Snares few. Here again we have an incline up which insects may be tempted.

The arrangement of the snares is so irregular that I will pass them by with a few words. These snares are sometimes absent; at other times they very from a few threads to a dense meshwork. Occasionally the arrangement is peculiar.

EXAMPLE XXVII.—Location: pile of vertical and horizontal logs. Main sheet irregular, nearly horizontal, arranged so that insects could pass from the top the logs on to the web. Gallery in one corner. Guard web absent. Snares abundant, at a short distance above the main sheet these threads from a horizontal network.

The secondary sheet cited in example XIII may be but an extreme of such a horizontal net work of snares.

A number of experiments have been made to test the spider's ability to vary the arrangement of its web to suit the environment. These experiment consisted in taking spiders from varions localities and subjecting them to a different environment.

EXAMPLE XXVIII.—A large number of spiders were placed in cylindrical bottles and left two days. Each bottle was closed with a perforated cork and only one spider was placed in a bottle. When captured some of these spiders were occupying triangular webs, some were occupying rectangular, and some were occupying irregular webs; but none were occupying circular webs. The majority of the spiders constructed webs. All the webs were circular. As a rule the webs were constructed near the top of the bottle. In all cases the gallery was against the side of the bottle, and penetrated from below. These spiders were now placed in a large box in which had been arranged facilities for constructing webs of any shape or size. The majority of the spiders died. Of the survivors, some built triangular webs, some built rectangular webs, others built irregular webs. Some of the webs were horizontal, some inclined. In some the gallery was in one position, in others the gallery was in a quite different position.

EXAMPLE XXIX.—Another lot of spiders was collected, care being taken not to collect any spiders that were residing in quadrangular webs. These were isolated in cylidrical bottles and left several days. The survivors constructed circular webs. They were now placed in the box used in the last experiment. Many died. The survivors constructed webs. A few of these webs were rectangular. Here, then, we have a case where the same individual successively constructed three differently shaped webs. This experiment has been repeated several times. Whenever the spider survived the ordeal the result was the same as here.

I now come to an experiment of a different sort.

EXAMPLE XXX.—In the angle between a projecting window-sill and the wall of the room, a spider had constructed a large triangular web. The gallery and a small portion of the main sheet were on the window-sill. With a broom I demolished that portion of the web which projected beyond the sill. During the night the spider reconstructed the web. The web was again destroyed, with the same result. This was repeated four times. But the fifth time, although the spider began to reconstruct the web, it only extended the structure a short distance beyond the sill. Was this variation a mere chance, or did the spider realize that there was danger beyond this sill and act accordingly? This is an isolated example.

EXAMPLE XXXI.—A tear was made in the free border of a triangular web. The spider patched the web.

EXAMPLE XXXII.—A large hole was made in a triangular web. The hole was situated near the free border of the web. During the night, the web was patched. In some unknown way the hole had been increased until it divided the free border of the web. The distal corners of the patch were attached to the supports a little above the former web.

Example XXXIII.—A small hole was made in the main sheet of nine different triangular webs. In each case the web was patched. The new spun web usually extended beyond the border of the hole but in no case did it cover the entire web.

Example XXXIV.—A large circular hole was made in the main sheet of three different triangular webs. A slender post was erected in the centre of each hole, care being taken not to allow the post to come into contact with the main sheet. One spider did not patch its web. The second spider partly patched it. The patch being attached to the main sheet and to two adjacent sides of the post. The third constructed a complete patch, attaching it to the main sheet and to the post

The three preceeding examples teach us that, as in the orb weaving spider[1] and in the purseweb spider,[2] so here, the spider patches its web whenever circumstances render it necessary.

Example XXXV.—An arachnarium was constructed in the following manner. Took a large battery jar and covered the bottom with moist sand to the depth of about one inch. Moist sand was then smeared on the sides of the jar, to within three inches of the top Such a jar formes an excellent arachnarium. Ordinary spiders can ascend the glass only so far as the sand extends. In the centre of the bottom a slender four inch post was erected. An angle was formed of paper and placed in the jar. The apex touched the side of the jar. The two extremities touched the jar on opposite sides of the apex and at a distance of about one fourth the circumference of the jar from the apex. This angle was about four inches high. A spider was taken from a triangular web and placed in this jar.

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1. *F. Dahl*—Versuch einer Darstellung der psychischen Vorgänge in den Spinner. *Vierteljahrsschrift f. Wiss. Philosophie.* Bd. IX, p. 162.

George J. Romanes—Animal Intelligence. pp. 211 (1883)

2. *Henry C. McCook*—Nesting Habits of the American Purseweb Spider. Proc. Academy of Natural Sciences of Philadelphia. 1888, part II, pp. 206.

A.—After two days had elapsed, the spider constructed a web the main sheet of which extended from the top of the paper to the top of the central post. There was no guard sheet. The spider concealed himself in a crevice between the paper and the side of the jar. There was no true gallery. But the main sheet, which extended over the top of the paper angle to the side of the jar, was pierced at one place by a cicular hole. Through this hole the spider came and went. At first this web occupied only half of the available space. But the next night the web was increased until it formed a complete horizontal partition in the jar. I destroyed this web.

B.—The web was reconstructed. In all essentials it agreed with the web first constructed. I destroyed this web.

C.—The web was reconstructed, but in a different part of the jar. This time the main sheet extended obliquely upwards from the floor to the side of the jar opposite the paper angle. The lowest portion of the web was near the central post, while the highest was opposite the paper angle and about three inches above the level of the sand. There was no guard web. The vertical gallery was built against the glass at the highest point of the web. This web was not disturbed.

D.—The above web had not been completed two days, before the spider remodeled it. The main sheet was extended horizontally from what had been the highest point of the web to the central post. The upper portion of the gallery was increased by the addition of a horizontal tube about one inch long and a half inch in diameter. Near the side of the jar the gallery expanded into a large room with a diameter, along the side of the jar, of from two to three inches The roof of the gallery was supported by tension strings which extended from the distal edge of the roof to the opposite side of the jar.

EXAMPLE XXXVI.—An arachnarium was arranged as above; but, instead of having one central post and a paper angle, four posts were arranged so as to form a square.

A.—One spider was placed in the jar. After the lapse of a few days a web was constructed. The main sheet was horizontal and attached to the side of the jar and the top of one post. A vertical gallery was constructed against the side of the jar. In a few days this web had been increased until the main sheet formed a horizontal partition in the jar. This sheet was attached to the tops of all of the posts. I destroyed this web.

B.—A small rectangular tube was placed on the ground between two posts. The web was reconstructed· This time the gallery was located on the ground near one of the uprights. The gallery was held extended by tension strings which extended from the sides of the gallery to the tube and to the side of the jar. There were two main sheets, one extending form each extremity of the gallery, outward and downward to the floor. During the second night a vertical guard sheet was erected, which extended from the gallery to the post diagonally opposite. A few days after this web had been completed the spider was disturbed while resting in the gallery. It immediately left it. The web was not injured in the least.

C.—The night following its hasty retreat from the gallery, the spider constructed another web. The main sheet was horizontal and on a level with the top of the posts. It was pentagonal, being attached to the jar, to three posts and to the upper edge of the guard sheet of the lower web. Where they met the main sheet of the lower they were completely fused. The gallery was an L shape tube It consisted of a horizontal portion extending along the sand, and of a sub-vertical portion ascending along the jar.

The two webs thus unequaly combined formed a two story house; and the L shaped gallery formed a stairway leading from the first to the second story. Indeed the spider used sometimes one story and sometimes the other. At one time it would await its prey in the upper gallery; while at another time it would await its prey in the lower gallery.

SUMMARY.

Various writers from Fr. Dahl[1] to McCook[2] have informed us that the orb-weaving spiders vary the structure of their webs to suit the environment, and that they patch their webs, when

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[1] Op. cit II.

[2] American Spiders and Their Spinning Work.

accident renders it necessary. The purseweb spider also patches its web. [3]

The above examples teach us that the gallery spiders conform to the same rule.

The main sheet undergoes all variations from a flat expanse [Ex. I] to a funnel shape bag [Ex. X–XII].

The main sheet may be either horizontal [Ex. II] or inclined [Ex. IV, VII].

In fence corners and other places where the environment is simple, the shape of the web is apt to be governed by the shape of the environment, [Ex. V–IX, XXI]; but where the environment is more complex, the shape of the web can not be predicted [Ex. III, XXXV, XXXVI].

A web usually contains but one main sheet, but on rare occasions the web may consist of two or more such sheets. In such cases the sheets may be fused into one compound sheet [Ex. XV, XVI, XVII, XVIII]; or the two sheets may be united by a common gallery [Ex. XIX]; or, they may so unite as to form a two story house [Ex. XXXVI, C].

The gallery may be located at any portion of the main sheet [Ex. III, V, VI, XII, XIX, XX, XXI, XXXVI]; sometimes the gallery is absent [Ex. XXXV, A].

In spite of all this variety, if individuals of the same species constructed similar webs, there would be no indication of intelligent action. But such is not the case. Under the same external conditions, individuals of the same species construct dissimilar webs [Ex. VII–IX; V, XXII].

Not only so, but under the same external conditions the same individual constructs webs that are quite different. At one time a spider may construct a flat web in which a hole in the main sheet supplies the place of a gallery [Ex. XXXV, A]; later, under the same conditions, that spider may construct a web with a very conspicuous gallery [Ex. XXXV, C].

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[3] *Henry C. McCook* Nesting Habits of the American Purseweb Spider. *Proc Acad. of Natural Sciences of Philadelphia, 1888, part II, pp. 206.*

At one time a spider may construct a web which contains but one main sheet [Ex. XXXVI,A]; later the same spider, under the same conditions, may construct a web with two main sheets connected by a common gallery [Ex. XXXVI,B]; still later the spider may remodel this web and transform it into a compound web having an upper and lower story connected by a special gallery [Ex. XXXVI,C].

The gallery spiders patch their webs, when accident renders it necessary [Ex. XXXI–XXXIV]. They also remodel their webs [Ex. XXXV,D, XXXVI,C].

The fact that all of these webs consist of a more or less expanded sheet to which a gallery is attached seems to indicate that there is an inherited tendency in gallery spiders to contruct galleries.

On the other hand, if instinct dictated the details of construction, then all webs constructed by individuals of the same species should be identical. But this is not the case. Even where the external environment is the same, webs of different individuals of the same species are often dissimilar. Furthermore, on the grounds that instinct is the only determining factor, how can we account for the fact that under the same external conditions, the same individual constructs dissimilar webs.

All things considered, I think we may safely conclude, that an instinctive impulse prompts gallery spiders to weave gallery webs, but the details of construction are the products of intelligent action.

THE PSYCHOPHYSICAL BASIS OF FEELINGS.

C. L. Herrick.

In a paper before the International Congress of Experimental Psychology, session of 1892, Professor Hugo Münsterberg details the results of experiments, showing that the emotional states react differently on the extensor and flexor systems of skeletal muscles. After having for some time practiced moving an index on a scale 10 or 20 centimeters centripitally and centrifugally until the distance could be quite accurately estimated with closed eyes, he tried the same experiment while experiencing pleasurable and painful emotions. The results are interesting. Purely physical variations, such as would be expected *a priori* are seen in the underestimation of the distance in dull or serious moods and over estimation when excited or amused. But psychical variations appear when they would hardly have been expected. Thus in unpleasurable emotions the extensor motions are too small while flexor motions are too large and during pleasurable emotions the flexor motions are too small and the extensor motions too large. The author does not hesitate to found on this observation the theory that it is not simply true that painful emotions produce flexor motions and pleasurable emotions extensor motions, but that the psychophysical effect of the reflexly produced extension and flexion is precicely what we term pleasure or painful emotion. A farther generalization is that extension must always, from the biological standpoint, occur with serviceable and flexion with harmful irritations.

Even the infusoria exhibit the same tendency. This lies at one extreme while at the other the pleasurable emotion of assent is but an associated reproduction of earlier extensor motions and *vice versa*. Pain and pleasurable sensations acquire emotional value only through the aid of associated muscle sensations i.e. such as form the foundation of our empirical ago.

It seems to us that this elaborate structure is somewhat heavy for the slender foundation in fact on which it is reared but this may be left for psychologists to decide. It is true that the subject of the physiological concomitants of the emotions are greatly in need of investigation. It has long been suggested that vaso motor changes have much to do with the emotions. The familiar fact that the peripheral vessels become congested in joy and anger alike has been used by Wundt to dispose of the theory of a psychophysical cause of the emotions. This whole subject of the vaso-motor changes accompanying emotion requires minute study. The general objection that the sensations accompanying emotions so far as they are due to changes in the blood pressure are insignificant and incapable of producing so striking an effect may be disposed of at once, for we are now taught that the imperceptible innervation sensations in the muscles of the eye ere adequate to determine our judgements and concepts of position and direction even in the dark. It is not inconceivable that changes of blood pressure may occur which now produce no direct sensations but which operate indirectly on the reflexes associated with emotions. That is that, instead of a localizable sensation, the stimulus finds its way to our consciousness in a form which we term pleasure or pain, anger or fear. What we wish here to call attention to is the fact that a habit of self-observation can be formed which will enable one to note the heretofore unsuspected richness and variety of sensations associated with vaso-motor changes. Even the vivid reproduction of a painful event may cause a variety of delicate and indescribable thrills accompanying waves of contraction passing through various regions of the trunk and limbs. But, to specify particularly, many of my readers will remember the peculiar sensations awakened in childhood by the presence of a pet cat or rabbit. If the recollection is sufficiently distinct you will remember the thrill extending through the entire body, tingling in the finger tips but especially strong in the visceral regions, to this were added almost tetanic contractions of various muscles with the impulse to seize the object and squeeze with the utmost force—an impulse only inhibited by the reflection that this would give pain to the object of affection, and among the most remarkable of these phenomena was strong contraction of the masseters and other jaw muscles accompanied by intense but pleasurable tingling at the roots of the teeth and in other nerves of the face. The sensation was so powerful as to constitute in my own case one of the most vivid recollections of childhood which is even yet occasionally reproduced in less degree. That this is not a personal idiosyncracy is proven by the testimony of others. I was told but yesterday by a close observer that his son habitually expressed pleasurable emotion by compression of the jaws. Everyone has observed and experienced the intense desire to press, squeeze, or hug objects of interest, particularly small animals or children to which diminutive terms are instinctively applied by all people. The grandmother who with difficulty restrains herself from pinching painfully her grand-daughter's cheek and the child herself as she hugs to death a favorite kitten illustrate a law which finds its morbid expression in gynophagia and the like. Here we have apparently a set of important exceptions to the law formulated by Professor Münsterberg, but particularly important evidence that the essential psychophysical substrate of the emotions is not formed of muscular reflexes of the two categories indicated.. The early localization of the affections in the bowels is founded on good physiological observation and we need much study of the sympathic system and its relations to emotional phenomena before the problem here indicated can be profitably discussed. It may be noticed in passing that the suggestion of Professor Münsterberg is not entirely new; Tuke, for example, says "By acting chiefly on the flexor muscles, fear causes the general bending or curving of the frame—analogous to the action of the hedgehog, etc.—while courage contracts the extensors, and produces expansion and height." "The opposite muscular states of contraction or tension and relaxation alike find illustration in the emotion of terror, for with the signs of the former already mentioned, and the stare of the eye, are combined the relaxation of the masseters, the sphincters and the processes of organic life." "Calmness— a placid condition of the feelings generally—is marked by a gentle contraction of the muscles, indicative of repose, but at the same time of latent power—by the countenance free from furrows, but not relaxed into weakness. Anger or rage contracts the masseters, inflates the nostrils, furrows the forehead, and exposes and rolls the eyeballs, clenches the fist, and induces a violent action and more or less rigidity of the muscles generally."

The following sentence is especially interesting as compared with the observations above referred to. "As all movements have for their great end the preservation as well as the enjoyment of the individual, and as contraction and relaxation take place primarily to attain this end, a general expansiveness of expression and gesture is allied with all the emotions which are excited by impressions (or generated by ideas) of a beneficent character, while a general exclusiveness or contraction of features is allied with emotions excited by maleficent expressions; the object of one class of movements being to court and receive, and of the other to avoid and reject." "Pleasurable and painful sensations from without determine, then, the form which the muscles called into action assume; the purpose being to protect the organs. Similar muscular changes arise from the emotions, according as they are pleasurable or painful, in consequence of the harmony between mental and bodily acts" (Influence of the Mind upon the Body, 1873, p. 152, *et seq.*)

INSTANCES OF ERRONEOUS INFERENCE IN ANIMALS.

It is no less instructive to observe the cases of incorrect mental processes in the lower animals than those which we recognize as intelligently accurate. The fact that animals make mistakes similar to those of which we are guilty, implies a similarity in the processes.

Some years ago it was our custom to drive a cow from her pasture into the stable each evening at sunset. On one occasion the horizontal rays of the sun passing through the opening for a rail shot a bar of yellow light athwart the opening about breast high. On reaching the door, eager for the expected food, the cow stopped short and lowered her head. The intense beam bore an unmistakable resemblance to a fresh pine bar closing the opening. In spite of repeated inducements *a tergo* added to the odor of the manger the beast declared her inability to jump over the obstacle without striking the top of the low door. We appealed to the material sanctions of authority with such effect that in sheer desperation she gathered her feet and her forces and made a frantic lunge over the supposed bar which offered no resistance. Safely past the obstacle, she turned in grave astonishment at her own prowess and seemed completely mystified at the ease with which she had vaulted over the bar which still remained in its place.

EDITORIAL.

INSTINCTIVE TRAITS IN ANIMALS.

It is proposed to open these pages to all data bearing on the mental habits or instincts of animals in the hope that those who have opportunity to observe the habits of domestic and feral animals will not hesitate to make a record of anything which in any way bears on those rudimentary psychical manifestations which may assist so materially in the difficult analysis of human activities.

One of the most serious drawbacks in the collection and employment of such data is the tendency on our part to project into the mind of the animal such of our own mental experiences as would be likely to be associated with the observed conduct. We are justly skeptical of the account which ascribes shame or modesty to an animal without careful analysis and definition of terms.

Professor Morgan has done good service to Comparative Psychology by his analysis of nomenclature which provides us with terms suited to the simple or at least unresolvable mental processes of animals. As an illustration of what we seek to secure in this column we have added a somewhat miscellaneous series of incidents, partly from a paper on the Mammals of Minnesota now appearing as Bulletin VII, of the Geological Survey of Minnesota.

The Play Instinct. The tendency to play, i. e. to resort to various sorts of activity which have no immediate or direct value in the animal economy, but simply afford subjective pleasure, is universal among mammals, at least at certain seasons. It is an instinct very deeply seated and associated with periods of redundant physical energy or nervous excitement. Thus it is most highly developed in the young, at certain times of the day and season, and at certain physiological acme.

James says, "All simple active games are attempts to gain the excitement yielded by certain primitive instincts, through feigning that the occasions for their exercise are there. They involve imitation, hunting, fighting, rivalry, acquisitiveness, and construction, combined in various ways; their special rules are habits, discovered by accident, selected by intelligence and propagated by tradition." This is the most scientific definition we have yet found and may be employed as a basis for an examination of our common animals. The simplest observation shows that play has its physiological condition in redundant physical power or excitement. No animal plays when fatigued or weak. There must be a supply of explosive material in unstable equilibrium which produces a nervous plethora. We may imagine that the constant nervous overflow which constitutes the tone of a healthy system gradually increases until it becomes in itself an active irritant—a sufficient cause for motion. It is one of the simplest law of physiology that the discharge of superabundant accumulation is always attended with more or less pleasure, the amount depending on the extent to which the discharge may be attended with important results to the individuals or species. The discharge of nervous and muscular power is no exception.

The simplest forms of play are due almost exclusively to exuberance of physical vitality. Thus when my three-months' kitten rises from its sleep, yawns and suddenly springs away, rushes across the lawn and climbs half way up the tree, and then, as if remembering the dignity of cat-hood climbs down and sedately returns to its nap, it may be be presumed that there was no consciousness of purpose or motive or definite objective point, but a mere impulse to activity which received its unconscious direction from the circumstances of its environment and sensations in its muscles.

But such blind, spasmodic, impulsive exercise is scarcely entitled to be called play. At most it seems to give us the hint as to the primary physical impulse back of play. What may be called the psychical condition is the absence of other forms of mental activity. If attention is otherwise occupied the instinct to play is inhibited. Strong incentive to hunt, like hunger, or great alertness, as when the attention is riveted on a hole and the slightly twitching tip of the tail is the only evidence of activity, are incompatible with the play instinct. These are the two fundamental laws, positive and negative, at the basis of the science of play. Nearly akin to the positive overflow of stored nerve force and its pleasurable accompaniment is the discomfort which in man is termed *ennui* which follows mental and physical inactivity. The nature of the physical element may be rendered clearer by an illustration. In this state of relaxation and aimlessness, the muscular tone is weakened and the accumulation of nervous force overflows spasmodically in yawning and stretching. The discomfort which, precedes these overflows is a genuine form of pain as the acts themselves produce a genuinely pleasurable sensation. In sleepiness we have a peculiar change in the vaso-motor centres which, when consumated produces a change in vascular tone causing sooner or later a slowing up of the accumulation and discharge. It appears to be due to the fact that the two processes are not simultaneously altered that the system finds necessary the paroxysmal discharge of the yawn, etc. Now, as we have seen, the delayed discharge has its painful accompaniment, so also in ennui there is a real physical complex of unpleasant sensations which have their counterparts also in the purely mental experiences of ennui.

Both forms of restlessness doubtless exist in animals and, when a suitable encitement is present, predispose to playfulness. Animals however, are much more prone than man, in the absence of external stimuli, to fall into a sort of hypnotic slumber so that they endure the monotony of confinement with less discomfort. Some animals accustomed to a life of constant and violent activity are exceptions to the rule, as witness the puma, and most strictly carnivorous animals of large size. Granting then that the play instinct is at bottom impulsive—that its origin is the overflow of accumulated vitality, how comes it to assume the playful form, what is the directive or modifying agency? It is here in fact that we reach the sphere of instinct. Those activities which must occur take the form for which the organism is best prepared. The preparation consists of hereditary tendencies, primary instincts. In the lower animals such an instinct is that of the chase. When the kitten, whose restless predisposition forces to activity, catches sight of its moving tail the instinct to seize or follow it is of this sort. It is unimpeded by any inhibiting judgement and when the motion produces an opposite motion in the elusory member the excitement of the chase grows apace. It must be remembered that the element which to us as on-lookers chiefly affords amusement i.e. the sense of the incongruous—the knowledge that every increment of effort in pursuit simply accellerates the flying tail, is absent to puss herself, she finds her enjoyment simply in the pursuit. This may be regarded as a simple case where a vital impulse is guided by a single easily explicable instinct. As the kitten grows older a habit of play is formed which serves to perpetuate the playful chase after its futility is more or less distinctly recognized by obscure or implicate judgements. In the demure matronly cat of experience such instincts are prevented by a variety of circumstances, 1st. the necessary duties of life remove the surplus vitality, 2d. the actual excitement of the chase is so much greater that it serves to depreciate the play exercise by contrast, 3d. some vague judgment of the incongruousness of the occupation may be felt just as a certain feeling of shame or "crestfallenness"is obvious when puss oversprings her prey. Occasionally, however, even sedate Grimalkin gives way momentarily to the impulse and it is amusing to see the sheep's eyes she makes when caught in her play. It would seem that she feels a genuine sense of incongruousness. Of course this is a point about which it is impossible to be very confident but I appeal to observers of the cat if such be not the appearance. We have so far employed the simplest and most familiar illustrations. It is obvious, however, that all instincts—all hereditary tendencies may influence the playful activities.

The pursuit of prey, as we have seen, is one of those activities which through heredity becomes instinctive in predaceous animals and thus becomes a determining factor in the development of playful habits. It should be instructive in this connection to compare the exhibitions of playfulness in the nonpredaceous groups with those already referred to. Observing the various groups of rodents, herbivora, etc. we are struck with the fact that their sportive movements are of a more rudimentary sort than those of the carnivora, consisting of more or less aimless gambols rather than the pursuit of moving objects. In other words the instinct of the chase is absent unless it be in its obverse expression.

Young guinea pigs or older individuals when liberated from confinement or when well-fed express their enjoyment by a series of curious convulsive kicks which remind one of nothing so much as the playful contempt of a stall-fed heifer on escape from leading. The same antics, in but slight modified form, prevail among the rabbits and most rodents (I have observed it even in *Geomys bursarius*) in the sheep, kine, horses, etc.

This, which may be briefly designated as the *gambol*, is present in carinvora in a more or less modified from. In Felidæ the animal arches its back and bounds up and down throwing the axis of the body now this way, now that, ending with a short rush. In the raccoon the same prancing with up-lifted tail is pronounced. I have observed something similar in foxes. Essentially the same motion is that of a child which "jumps up and down" with pure gaiety. So wide-spread a form of spontaneous expression of redundant energy must have an elementary character but slightly in advance of the skurry at first described. In non-predaceous animals the next most characteristic play antic is simulated flight. Even guinea pigs delight to wander a short distance from home and then scurry back in well-imitated consternation; colts, calves, and lambs select some point as a danger ambuscade and make inquisitive forrays and fly in great disorder from foes of their own imagining.

It requires no special explanation that the overflowing energy should be controlled by the inherited instinct of self-preservation. At first thought, it may seem strange that what in itself must be a most painful experience—fright—should form the staple of a play exercise which is expressive or productive of pleasure. Very many of the amusements of children owe their fascination to the element of danger, real or simulated, the escape from which affords a sudden relief from tension which is essentially a pleasurable stimulus. To this add the egoistic satisfaction of escape due to our powers, exertation or acumen. How far can such egoistic elements enter into the experience of lower animals?

The extent to which the agressive and defensive or fugitive element enters play exercise is a good index of the habits of an animal May it not also serve to give the attentive parent or teacher a clue to the mental disposition of the child?

Even in non-predatory animals, however, there is developed a tendency to pursue, but as a rule these seem to be due to vague amatory instincts which develop before their distinctive criteria. Careful observation will be useful along the lines here suggested. Closely correlated with this phase is the combative play of nearly all animals. This is of two kinds and the distinctions must be carefully drawn to make observations of any value. The playful butting and kicking of herbivora and the nagging of other animals in the same litter can be traced to inherited instincts of competitive strife with others of the same sex. Often the early simulation very soon graduates into the reality, as in cockerels of the same yard, while in other cases the sedateness of maturity obliterates the play, which reappears in reality with the annual occasion therefor. The other class consists of imitations of conflict with competitors of other species or powerful prey. The kitten which crouches behind a bush and rushes out with great bounds upon its mate who is creeping toward it and then rolls over in vigorous thought velvet struggles to overpower it experiences something of the joy of battle which will glorify the real war with rat or gopher. Where parent and progeny thus play, as do the bears especially, there is also the (unconscious ?) element of instruction involved.

Social instincts greatly modify the play impulse and, of course, these vary with the gregarious or solitary habits of the animal in question. In solitary or monogamous animals the social play is confined to the young of the same litter, though when circumstances being unrelated animals intimately together they may learn to play among themselves. In gregarious animals the young play promiscuously for a time. In animals which form communities the communal nature soon becomes characteristic of the play. Troops of lambs follow the adventurous leader until such time as parental anxiety or other influences cause them to fly tumultuously back to their mothers.

One of the early instincts of a social sort is a compound of acquisitiveness and rivalry. The young of many animals go through the motions of hiding articles before they have definite judgements as to the service of the hiding, indeed the instinct often remains throughout life much more prominent than necessary to the regime of the individual.

As bearing on the acquisitive habits of mammals the following account is quoted from a sprightly article in the *American Naturalist*, by Ira Sayles. (Am. Nat. vol. iv, p. 249.)

"I lately noticed in my garden a bright-eyed chipmunk, *Tamias striatus*, advancing towards me. . . Here he paused a moment and gave a sharp look all around him, as if to detect any lurking spy on his movements. (His distended cheeks revealed his business; he had been out foraging.) He now put his nose to the ground and, aiding this member with both fore paws, thrust his head and shoulders down through the dry leaves and soft muck, half burying himself in an instant.

"At first I thought him after the bulb of an Erythronium that grew near. . . Presently, however, he became comparatively quiet. In this state he remained, possibly half a minute. He then commenced a vigorous action as if digging deeper; but I noticed that he did not get deeper; on the contrary, he was gradually backing out. I was surprised that in all his apparent hard work (he worked like a man on a wager) he threw back no dirt. But this vigorous labor could not last long. He was soon completely above ground, and then became manifest the object of his earnest work; he was refilling the hole he had made and repacking the dirt and leaves he had disturbed. Nor was he content with refilling and repacking the hole. With his two little hand-like feet he patted the surface, and so exactly replaced the leaves that, when he had completed his task, my eye could detect not the slightest difference between the surface he had so cunningly manipulated and that surrounding it. . . It was now my turn to dig, in order to discover the little miser's treasure. I gently removed enough of the leaves and fine muck to expose his hoard—half a pint of buttercup seeds, *Ranunculus acris.* I took out a dozen seeds or so, recovered the treasure as well as my bungling hands could, and withdrew, filled with astonishment at the exhibition of cunning, skill and instinct of the little much abused denizen of our field borders."—[Mammals of Minnesota, p. 160.]

Obeying the acquisitive impulse, young animals seize an object (perhaps a bit of paper) and are frantically pursued by their fellows who bear down on it and rush off in triumph with their useless spoil and hide it with painful care.

The constructive instinct begins to display itself in many animals very early and always in ways more or less suggestive of inherited predisposition. Thus the young beaver when confined away from others of its kind as well as out of sight of water nevertheless goes through the motions of dam-building with whatever materials may be convenient. But such efforts as these grade so easily into the serious work of life for which they are the fit preparation that we soon pass beyond the limits of our subject.

An interesting article in the *Open Court* for June 9th, 1892, gives a description of the development of the play impulse in a litter of Scotch Collie puppies and illustrates many of the points above mentioned. Especially interesting is the application by the mother of her acquired instinct for herding to her play with the puppies.

"When six weeks old the mother recognized that it was time for frolics, and she would enter into the game with curious delight, and evident effort to lead them. The Collie instinct was strong to keep them herded, as she would herd sheep. If one wandered she rounded him in. Then jumping out of the middle of the nine puppies she would drop down and tempt them about her again. Soon the game, much like boys' game of tag, became extremely lively—but all the time she never neglected herding. Here were two instincts coöperating, or perhaps conflicting, the one acquired from civilization and domesticity; the others much older. At about two months of age the pups began to show marked individualities both in play and otherwise. One or two sought human friendship much more markedly than the others, running to me to be fondled rather than to wrestle with their mates. Two from an early age manifested a quicker sense of sport than the others; and would challenge the crowd, dashing about with tails wagging and with growls, and dancing into any pup they met."

The so called musical performances of animals may be regarded as expressions of the same category as play.

The resort to some sort of vocal sounds as an expression of pleasure in activity is almost universal. Even the mice and shrews have their melodies. In general these sounds may be compared to those made by many men when settling themselves to repose after great fatigue or the grunts of satisfaction emitted by the heated laborer during his ablutions, but some species have complicated melodies at their command.

Dr. Samuel Lockwood in the "American Naturalist" for 1871 contributes a delightful chapter on the musical capacities of the wood mice. From this we quote as follows:

"A little study soon determined that the pretty creature belongs to the Vesper mice. It is known by the popular names of Jumping mouse, Wood mouse and White-footed mouse. Our specimen is one of the smallest of its own genus, for the precise species is the one known to naturalists as *Hesperomys cognatus* Leconte. This fact, so novel, once determined gave additional zest to my purpose to make it an object of especial study.

"Our little musician had several snatches or bits of melody which were often repeated. But in her *repertoire* were two notable ones, each of which deserves to be dignified as a professional *role*. The one by far the more frequent is noted below, and because it is her favorite, when running in her revolving cage, it was named '*The Wheel Song.*'

"The last bar of this would frequently be prolonged to two or three, and she would sometimes change from *c* sharp to *d*, to *c* natural and *d*, then warble on these two notes awhile and wind up with a quick chirp on *c* sharp and *d*. The distinctions between the semi-tones was very marked and easily appreciable to a good ear. I have always enjoyed the mellow little strains of the song of the sparrow and the house wren. But in either case it was short and apt to become monotonous from its admitting almost no variation. Monotony was not chargeable to Hespie's Wheel Song. With unconscious skill she would work it out in wonderful variety. Instead of the first measure, she would sometimes open with the second one and then follow it with the first. Or she might start with the third, following with the second or first, just as fancy seemed to dictate. Then she had her whims as to the amount of repetition of each bar, that is to say, she would double or even triplicate a measure when the notion took her. In this regard, time was quite ignored. Indeed, whatever may have been the *Hesperomys*' canon of musical procedure or propriety, we could not but regard it as arbitrary, or beyond our comprehension. Still, it must be admitted that this little performer possessed precision, delicacy and scope of execution."

"She had one role, which although the notation is simpler than that of the Wheel Song, yet I think, to her, its execution was more difficult. It is certain that she was far more chary of its performance, and to me its effect seemed more impressive. I have, on account of its infrequency, distinguished it as '*The Grand Role.*'

"This was seldom given, yet quite often enough to allow it to be written down. The second measure would be sung quite fast, sounding almost like the pecking of a woodpecker on a tree, and at other times it would be slow like the dropping of water. Although she had no ear for time, yet she would keep to the key of *b* (two flats), and strictly in a major key. This fact I consider interesting, as Wood declares his belief 'that the untaught cries of all the lower animals, whether quadrupeds or birds, are in the minor key.' Herein theory must yield to observation. If I might venture an opinion, it would be that the music of the really musical wild animals is oftener on a major key, while the minor key characterizes savage man. A remarkable fact in the above role is the scope of little Hespie's musical powers. Her soft, clear voice falls an octave with all the precision possible; then, at the wind-up, it raises again into a quick trill on *c* sharp and *d*.

"Though it be at the risk of taxing belief yet I must, in duty, record one of Hespie's most remarkable performances. She was gamboling in the large compartment of her cage, in a mood indicating intense animal enjoyment, having awoke from a long sleep, and partaken of some favorite food. She burst into a fullness of song very rich in its variety. While running and jumping, she rolled off what I have called her Grand Role; then sitting, she went over it again, ringing out the strangest diversity of changes, by an almost whimsical transposition of the bars; then, without for an instant stopping the music, she leapt into the wheel, started it revolving at its highest speed, and went through the wheel song in exquisite style, giving several repetitions of it. After this she returned to the large compartment, took up again the Grand Role, and put into it some variations of execution which astonished me. One measure, I remember, was so silvery and soft that I said to a lady who was listening, that a canary able to execute that would be worth a hundred dollars. (I occasionally detected what I am unable to explain, a literal dual sound, very like a boy whistling as he draws a stick along the pickets of a fence). So the music went on, as I listened, watch in hand, until actually *nine minutes had elapsed.* Now the wonderful fact is, that the rest between the roles was never more than a second of time, and during all the singing, the muscles could be seen in vigorous action through the entire length of the abdomen. This feat would be impossible to a professional singer, and the nearest to it that I have seen was the singing of a bird in the grove.

"For several days the wheel grated on its axle. This afforded Hespie great delight, and her own little warble was completely lost in the harsher sound. It was pretty much as it is with some of the modern methods of praise, as when the vocal is subordinated to the instrumental, a mere murmur of song, on which the organist comes down as with the sound of many waters. A drop of oil, and the sound of the friction stopped. This quite excited her temper. and she bit at the wires of her wheel most viciously. A little device was hit upon which set her in good humor again. A strip of stout writing paper, half an inch wide, was pinned down in such a way that its clean-cut upper edge pressed against the wires of the wheel, making with its revolution a pleasant purring sound. It was on the principal of the old time watchman's rattle, and the old toy known as a cricket.

"This for a while greatly delighted the capricious creature, and she made the wheel almost fly ; at the same time, in unison with the whirr of the wheel, was her own soft, cheery warble. It was very low, yet very distinct. I remember once on a larger scale witnessing an analogous sight, when, unseen, I entered a room in which was a women spinning wool, and singing at the top of her voice, in keeping with the loud whirring of the spinning wheel. Without her wheel the domestic life of little Hespie would be rather monotonous. . . . We next shut her out of the wheel by corking up the entrance. She worked desperately at the closed aperture ; then in despair gave vent to a piercing little cry. It was surprising what a strange pleasure this sound afforded me, it showed so clearly the difference in the timbre or quality of the sound of distress from that which I have called its singing. She was a good deal excited, and ran frantically into and out of her little bed-box, which had a hole at each end. Soon this tiny gust of rage passed over. She now, though running about her cage, indulging in little gambols, indicating grace and agility, struck off into a truly beautiful strain of song. It occupied about three minutes, and had in it considerable scope and variety. First, there was a clearly enunciated expression like that of the cooing of a turtle dove, a soft note with a deliberate slowness. This changed into a series of more rapid notes strangely suggesting the not so weird-like, conchy clamor of the American cuckoo (*Coccyzus*), then closing with a series of short, rapid- sounds like the tapping of a woodpecker on a tree." "A very noticeable fact was, that a great deal of this little creature's song was poured forth while at play, that is, while in actual activity; and, take the wheel play, for instance, when really in quite violent exercise. A thing, too, which much surprised me, was, that often when eating she sang and ate at the same time, literally in the same breath. This singular habit, so suggestive of a great physiological difficulty, led to an incident, which caused considerable merriment for those who witnessed it. I had been examining some insect larvæ on a twig of black alder. Without any real motive, a bit of the twig, about an inch long, and an eighth of an inch thick, was offered Hespie. She was delighted and at once began in her usual pretty way, sitting up, to eat the bark, although it is very bitter. Thus she sat "bolt upright;" and the manner in which she held this little black stick in both her hands up to her mouth, at the precise angle at which a fife is held, although nibbling away, yet singing at the same time, it looked so like a little fifer playing on an ebony fife that laughter was irresistible at the comical sight."

"Wishing to see how this Hesperomys would behave in company, I put into her cage a young domestic mouse about one third grown. She was asleep in her little box. When she awoke it was a pretty sight. What animation! How the black eyes started and sparkled! To me they seemed to snap with fire. The whole frame was in a quiver—first of astonishment, then with rage. It was not a run—but a jump which she made at the little involuntary intruder, who received a nip that made it squeal in terror. We removed the little captive, who was so astonished that it was quite content to lie in our hand. Its terror had won our pity, and we restored to it its liberty."

Although the particular mouse, above so pleasantly described, came from Florida, it is certain that the musical powers are not confined to any section, for several different species of various genera have afforded examples of more or less highly developed musical powers, as witness the following note quoted from the *American Naturalist* of 1871, p. 171:

"A communication in the *Naturalist* some time ago in regard to musical mice, prepared me for a phenomenon which recently came under my observation, which otherwise would have astonished me beyond conception. I was sitting a few evenings since, not far from a half-open closet door, when I was startled by a sound issuing from the closet, of such marvelous beauty that I at once asked my wife how Bobbie Burns (our canary) had found his way into the closet, and what could start him to singing such a queer and sweet song in the dark? I procured a light and found it to be a *mouse!* He had filled an overshoe from a basket of popcorn which had been popped and placed in the closet in the morning. Whether this rare collection of food inspired him with song I know not, but I had not the heart to disturb his corn, hoping to hear from him again. Last night his song was renewed. I approached him with a subdued light and with great caution, and had the pleasure of seeing him sitting among his corn and singing his beautiful solo. I observed him without interruption, for ten minutes, not over four feet from him. His song was not a *chirp*, but a continuous song of musical tone, a kind of to-wit-to-wee-woo-woo-wee woo, quite varied in pitch. While I observed him I took for granted that he was a common house mouse (*Mus musculus*), but when he sprang from the shoe to make his escape he appeared like the prairie mouse (*Hespyromys michiganensis*), a species I had not, however, observed before indoors. I have thus far failed to secure this little rodent musician, but I shall continue to do all I can in the way of popcorn to entertain him, and if his marvelous voice gives him the pre-eminence in mousedom which he deserves, by the aid of natural selection I shall presently have a chorus of mice ; in which case you shall receive their first visit. —W. O. Hiskey, Minneapolis, Minn."

The writer has been informed of many similar cases, making it certain that the musical performances described above, are in no way exceptional, but showing that considerable musical powers are universal among *Hesperomys*. That the song is not a voluntary expression of pleasure has been suggested by many. The most recent data in favor of the pathological nature of mouse music has been offered by Mr. Davis.[1]

While wandering about the house its tell-tale song gave notice of its wanderings. "When removing it from the trap to the cage, and many times afterward, it ran about a small room, and the most noticeable feature on these occasions was the unvaried song, it being especially loud if I caused the mouse to scamper around the room several times without stopping. When gnawing upon the exposed wood in the cage, when eating, or when disturbed in its nest, this singing was particularly loud ; in fact, upon any exertion, the song was produced, varying in volume in proportion to the amount of exercise."

"It was just previous to, and for some time after the birth of two miserable little young that *Mus* sang most continuously."

It would be of great interest to determine by anatomical examination whether the singing mice are suffering from bronchial disease.

That the shrews have considerable musical powers was first discovered by the writer under circumstances elsewhere published as follows :

"In November, 1883, the writer lay encamped under the canopy of the sky in Pine Co., Minnesota, endeavoring to escape the chill of the frosty air by drawing the blanket close and hovering nearer the camp fire. To a person alone in the woods for the first time after a long interval every sound is novel and more or less charged with mystery. The wind stirred the tree tops and impinging boughs clattered and the trunks groaned under the tortion, each tree with its own doleful note. The

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[1] Wm. T. Davis. The Song of the Singing Mouse. *Am. Naturalist, 1889, p. 481.*

few remaining pines added their sighing to the many melancholy sounds belonging to an autumn forest at night. But amid all the sounds nothing could be identified as coming from anything living, even the distant howling of wolves was silenced, and I began to feel that the attempt to gain personal knowledge of the ways of woodsy mammals by night study would prove futile, and composed myself to sleep. The half-somnolent revery which forms the prelude to slumber, was broken by faint melodious sounds on an excessively high key—so high that it seemed that I might be simply hearing the lower notes of an elfin symphony, the upper registers in which were beyond the powers of human ears to distinguish. The sounds were distinctly musical and reminded me of the contented twitter of birds finding resting places among the boughs at night. Without moving, I turned my eyes upon the fire-lit circle, about which the darkness formed an apparently impenetrable wall. Only the most careful scrutiny enabled me to discover the tiny musicians. Within a few feet of my head, upon a decayed log, raced a pair of shrews (*S. cooperi*), so minute as to escape my observation at first. Up and down with the most sprightly imaginable motions they ran, twittering incessantly. Hither and thither they scampered over my clothing and almost into my pockets, like veritable lilliputians, seizing now a crumb of cheese, with which my traps were baited, and now a bit of fish fallen from my improvised supper table. During the eating the conversation was not interrupted. The little visitors were not bashful about criticising the housekeeping of their host, if their apparent amusement can thus be interpreted, but it was a most good humored little party nevertheless which thus unceremoniously ransacked my larder. The party increased in numbers and merriment, until I was almost forced to believe myself an uninvited guest within the magic circle of Queen Mab's domain. I watched with interest the result of their intrusion into the traps which stood about for the capture of any red-backed mouse that might invade my camp, but Sorex passed entirely within, and, daintily arching his back, contentedly nibbled the cheese, and when the spring rose usually suffered but a short fright, and returned to finish the interrupted meal. Canned fish seemed to be more acceptable than any other food I had to offer. Tiring of the watching, I again lay down to sleep, during which time elfin voices sounded in my dreams. About midnight one of the little imps sprang across my face in so violent a way as to partially waken me, and thus, as good fortune had it, I was awake sufficiently to recognize the meaning of a sharp crack over head and sprang out of my bed in time to see it occupied by a massive tree-trunk which the fire had burned off not far from the ground."—Mammals of Minnesota, p. 41.

In the case of these shrews, the notes were very high, as in the bats, but quite musical and evidently expressive of pleasure.

From the musical expressions it is but a step to *the language of animals.* The most important recent addition to our knowledge of this subject is afforded by R. L. GARNER in his "Speech of Monkeys."[1] This volume combines in a pleasant manner interesting anecdote and suggestive data which seem destined to prepare for genuine advance in the investigation of the laws of communication of animals. That such communication exists no one familiar with animals can doubt, but our author seems to identify a number of specific elements in what may be legitimately termed speech. The nature of this evidence may be gathered from the following extract.

"The sounds which monkeys make are voluntary, deliberate, and articulate. They are always addressed to some certain individual with the evident purpose of having them understood.

"The monkey indicates by his own acts and the manner of delivery that he is conscious of the meaning which he desires to convey through the medium of the sounds. They wait for and expect an answer, and if they do not receive one they frequently repeat the sounds. They usually look at the person addressed, and do not utter those sounds alone or as a mere pastime, but only at such times as some one is present to hear them, either some person or another monkey. They understand the sounds made by other monkeys of their own kind, and usually respond to them with a like sound. They understand these sounds when imitated by a human being, by whistle, or phonograph, or other mechanical devices. and this indicates that they are guided by the sounds alone, and not by signs, gestures, or

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(1.) Charles L. Webster and Co., New York.

psychic influences. The same sound is interpreted to mean the same thing and obeyed in the same manner by different monkeys of the same species. Different sounds are accompanied by different gestures, and produce different results under the same conditions." "Each race or kind of monkey has its own peculiar tongue, slightly shaded into dialects, and the radical sounds do not appear to have the same meaning in the different tongues. The phonetic character of their speech is equally as high as that of children in like state of mental development, and seems to obey the same laws of phonetic growth, change, and decay as human speech." While the present writer has been unable to see that data adequate to prove the last statement are at our disposal, the methods given certainly tend to confirm the general drift of these aphorisms.

One of the most instructive of the experiments recorded is the following: "I secured a very fine phonograph record of the food-sound of the Rhesus monkeys belonging to the park. During the following night there arrived at the park a shipment of Rhesus monkeys just from their home in the east of Asia. There were seven of these new monkeys, three adult females and four babies, one of whom was left an orphan by the death of its mother on the passage across the ocean. At my request the superintendent had these monkeys stored in the upper story of the old armory building. They had never seen the monkeys in Central Park, nor had they been brought near enough to the monkey-house for them to learn by any means that any other monkeys were there. About sunrise I repaired to this room where I had my phonograph placed in order, and I enjoined those who were present by special permission not to do anything to attract the attention of the monkeys, nor under any condition to show them food or anything to drink.

"Having arranged my phonograph, I delivered to them the sounds obtained on my cylinder which I had recorded on the day preceding. Up to this time not a sound had been uttered by any inmate of the shipping cage. The instant my phonograph began to reproduce the record, the seven new monkeys began to answer vociferously. After having delivered this record to them, I gave them time to become quiet again. I showed them some carrots and apples, on seeing which they began to utter the same sounds which they had uttered before, and this time I secured a good record of their sounds to compare with the others."

We refer the reader to the volume for much interesting matter. A profitable field for study exists in the communications of other animals.

While speaking of the language of animals it would be unfair to neglect their songs. One of the most pleasing excursions into a new field is the attempt at notations of bird music in Cheney's Wood Notes Wild.[1]

The book is delightful, it breathes the enthusiasm of a poetic soul for nature's melodious solitudes. It cannot fail to revive the charm of many a Spring morning. Unfortunately neither the author's descriptions nor his musical notation can revive the ecstacy for one who has not experienced it. The inadequacy of the musical notation grows out of the fact that the timbre and accidence of bird music are as important as its melody and more characteristic. Moreover bird music is Wagnerian and depends on the setting. Our author recognizes this and gives the initiated imagination the stage directions with the score, as "In a deep forest" "signal for flight," etc. Our author's soul was full of music and he could hear it everywhere, as witness the notation of water dropping from a faucet into a bucket, the squeak of a door or a clothes horse. There is something lacking in the experience of one who cannot appreciate such bursts as these: "Occasionally, on reaching the hight, the song bursts like a rocket, and the air is full of silver tones." "Does one attempt to steal the enchanter's notes, he is anticipated, and finds himself stolen, heart and all the senses." The volume is enriched by voluminous notes and copies of all known notations of bird music and a full bibliography. It opens the field for a comprehensive study of animal phonetics. Peculiar aptitudes and a wide range of preparation will be necessary for such work but there can be no doubt that it will prove remunerative. The application of the phonograph and experimental imitation of the organs of song based on the now ample anatom-

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(1.) CHENEY, SIMEON PEASE, Wood Notes Wild, Lee and Shepard, Boston, 1892, $2.00.

ical data respecting the syrinx and other vocal organs of birds are desirable but will not take the place of critical musical training and familiarity with the modern science of phonetics.

Among the recent additions to the data of *entomological psychology* none are more interesting than the notes published by P. H. Dudley in the Transactions of the New York Academy of Sciences for 1889. The observations reported were made in Aspinwall, U. S. Colombia, by Mr. J. Beaumont, and are apparently trustworthy. The immediate occasion for the study is found in the extensive ravages of the Termites upon the property of the Panama railroad. Almost all kinds of wood used in the construction of cars, furniture and building being ruined by the burrows of these insects which build their nests upon the stem or branches of the trees and extend their galleries several hundred feet in search of food supplies. When these galleries are broken, a number of soldier or nasuti ants appear and arrange themselves in defensive order about the breech, while the workers which labor under the direction of the former repair the gallery. The workers appear with a bit of earth which they press upon the injured edge and then turning exude a drop of adhesive secretion upon the grain. Working from both sides the wall is soon joined in the middle. Should it happen that the broken edges have dried in the sun the insect first expresses the fluid on the margin then places his brick and covers it with his secretion as before. After a gallery had been broken a small black ant was pinned in the breech. This caused considerable excitement. "The nasuti soldiers approached it very cautiously with their feelers and seemed afraid of it. In a few moments a worker came with prepared glue, barely touched it, then turned round and dropped a speck of glue, then another, and so on until six had done so; then some grains of sand were brought and placed on the ant, which was now securely glued down." Soon the work on the gallery was resumed and the prisoner immured in his cell of sand and glue left to his fate, while the broken ends were connected by a curved portion so constructed as to altogether avoid the obstacle.

An interesting description of a battle between different species is given. The soldiers seem to direct the workers and urge them to the fray. They do not appear to fight or work.

Termitariums were formed by supporting a nest upon a branch in a battery jar. "On the second day, a scouting party of soldiers on the top of the nest looked up anxiously to the top of the jar, and waved their antennæ upwards, standing on tip-toe. They kept this position a long while, while others were running up and down. I soon divined their intention to be to find a way of escape from the jar. Meanwhile, thousands of workers were eating the wood and working at nest-building as though they intended to stay there; not one appeared to be idle, sick, or even tired. On the evening of the second day, I saw a party of workers starting a track of cement up the side of the jar, using no soil, only their secretions, which showed through the glass, like brownish frosting." "The next day, they commenced two tracks up the sides of the jar, by backing up as high as they could reach with the extremity of their abdomens, and then making a deposit of their glutinous secretions. Each one would go up head-first as high as it could climb on the secretion, and apparently mark the place of deposit, then turn around and back up again." The termites recognized instantly parts of their own community after being a long time separated. "I laid a piece of lead-pencil on the soil of my Termitarium. They at once formed a procession of inspection from either end, and in passing each other they would drop from the smooth surface at about the rate of one each second In a few moments the glue was called for, and they stood upon their heads on each side, reaching up with their abdomens, dotting the sides and others on the surface. In a short time there were none falling, the pencil was specked all over." This observation is especially instructive as showing, like the method of escaping from a smooth glass jar, a definite intelligent adaptation of means to an end in an unfamiliar exigency.

The suggestion that these insects are chiefly guided by the sense of smell is strongly confirmed by the following passage: "I have been observing the use they make of their antennæ, by causing a large drop of water to fall on a worker, which completely covered it for an instant, and made its antennæ curl up and stick to its head. It moved aimlessly about, apparently quite blind, until another worker, noticing its helpless condition, commenced at once to lick it dry, and then straightened its antennæ, upon which it walked away as though nothing had happened. Very different was the next experiment. I immersed in water for about two minutes another worker, then took it out and laid it on dry paper a moment, then returned it to the Termitarium, placing it on a chip. It was just able to stand. Four soldiers were first to approach and notice it; one ran to the nest, the other three stood at a distance of about three eighths of an inch, waving their antennæ, evidently smelling that something was wrong, but careful not to touch it. Presently a worker came out of the nest and cautiously approached, touched it with its antennæ, then gave it a cruel nip with its mandibles on the head and went away. The poor sufferer remained motionless all the time, apparently blind and not knowing what to do. A second worker came cautiously, as did the first, and touched it with its antenna, then suddenly seized it by the thorax and severed its head, without a struggle. The executioner then turned around and deposited a drop of the ever-ready cement on the headless body and walked away." In reply to the author's query, "Did they kill it to end its misery?" we would suggest that the bath in water had deprived the unfortunate worker of the odor which constituted its passport to a place in the nest and was therefore *anathema marenatha* to its former comrades. The patience with which the soldiers are groomed and fed by the workers is also well illustrated in this article.

May we not hope for many more detailed observations of a like nature?

A curious instance of instinctive adaptation was noticed by Mrs. Herrick which, though it may be familiar to many of our readers, is mentioned to indicate an interesting line of investigation. It was found that in a number of the flowers of the garden nasturtium (*Tropæolum*) small yellow spiders had built their webs in such a way as to obstruct the honey tube. In one case a small (young) spider, apparently an *Erigone*, had constructed an oblique web from the two unfringed petals to the base of the stamens in such a way as to cut off the access to the tube, *Fig. 2, A.* In another case in which the spinner was not seen (though a small black spider of the *Thomisidæ* was caught in the tube) the bases of the stamens were bound together and a few snares thrown across the opening of the nectary. The spider apparently lived in the nest at the base of the stamens, *Fig. 2, B.* It is not likely that these spiders had ever before encountered the *Tropæolum* but both succeeded in availing themselves of the opportunity with great skill. See article by Mr. Turner above.

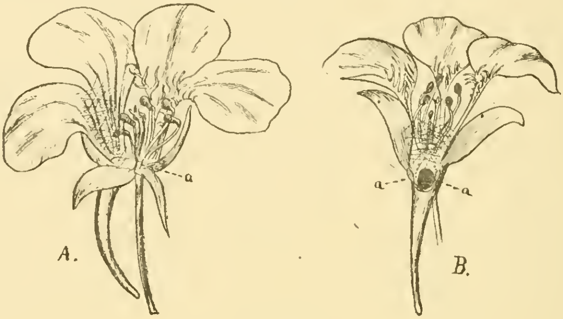

Fig. 2.

A second instance of adaptive modification of spider habits was also observed by Mrs. Herrick. The polished mirror of the sideboard in our dining-room was found decorated with lace-like tracery of extreme delicacy. The pattern of this fabric was narrow and formed several bands which extended in an obliquely perpendicular direction Close scrutiny showed that these patterns were veritable spider-ladders by means of which the upper and lower parts of the frame were placed in ready communication. The spider was not seen but, from the way in which the ladder was arranged in a zig zag line, taut in one direction and loose in the other and attached only at the angles, it was inferred that it was constructed while laboriously climbing or descending by reaching as far as possible with the hind leg on one side and attaching by an adhesive loop, then with the foot of the opposite side in the same way. The plate glass is highly polished and the web seemed to adhere with difficulty as indicated by "dropped stitches" here and there and irregular deviations in the path. There were five such tracks, of which two crossed others in their course, each 4—5 millimeters wide and about 40 centimeters long, crossing the glass. The spider seemed to live in a crevice above the mirror and required to cross the surface often. A loose thread hung from the frame above to the shelf below and seemed a more expeditions ferry. The instance is mentioned in the hope that other observations may be forthcoming. It is possible that the tracery was intended for the attachment of a web.

HISTOGENESIS AND PHYSIOLOGY OF THE NERVOUS ELEMENTS.[1]

C. L. Herrick.

Structurally the nervous system may be said to consist of a single remarkably constant element—the *neuron*. The neuron is fundamentally a cell with a certain amount of unstable protoplasm which may suddenly be excited to an explosive form of decomposition which propagates itself at the comparatively slow rate of 33 yards a second along the nerve fibres which are immediate outgrowths of the cells. Every such cell has one or more tube-like prolongations of its protoplasm forming the nerve fibre or "axis-cylinder" and also a number of branching root-like projections, or "protoplasmic processes." The latter terminate in minute fibrils which serve to connect the cell with its neighbors and other nerve paths. Although once supposed to serve the nutrition of the cell, it seems quite certain that these minute fibres transmit nervous stimuli to adjacent organs.

It is interesting to recall that, in the early stages of development, all nervous structures are derived from special portions of the surface of the embryo and that all the neurons, whether destined to form the retina or olfactory epithelium or to become a part of the mechanism of voluntary processes in the hemispheres, arise as products of cell-division from this primitive nervous epithelium. By a process which may be aptly compared to the formation

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[1] Reprinted from The Denison Quarterly, with the consent of the Editor.

The type here used is that which will be employed in Vol. III.

of a living rope by interlocking hands, the neurons unite in chains serving to connect distant parts of the nervous system. Each portion of the body has its representative in some portion of the nerve tube (spinal cord and brain) so that even in man a segmental or jointed character may be ascribed to the nervous mechanism. These several segments are capable of acting independently of each other and of consciousness, as may be demonstrated in reflex responses. The nerve paths are of two sorts, centrifugal and centripetal, i. e. adapted to convey stimuli from and toward the central organ. It is true also that in the nervous centres there are neurons concerned with the centrifugal (motor) and centripetal (sensory) currents. It appears certain that there is a permanent and important difference in form and function between the kinesodic (originative) and æsthesodic (receptive) centres and systems.

It is a remarkable fact that either of these systems may be diseased within the spinal cord without affecting the other. Thus in "tabes" all the sensory fibres of the spinal cord may degenerate, destroying sensation, while the muscular power is unaffected.

In other cases descending degeneration may paralyze groups of motor nerves while sensation is unaltered. Sensations of heat and of pain may pursue other paths than those of tactile sense.

While it is true that the spinal centres may act independently it is also true that during normal states the higher and especially the voluntary centres exert a remarkable "inhibitory" control. The constant repressive, conservative action of the hemispheres is most important to normal activity.

In its relations to the body at large the brain and central system is much more than the servitor of an active intelligence, for throughout life there is a constant overflow of nerve force which keeps blood-vessels and muscles in a state of tonic contraction which is delicately adjusted to every fluctuating external and internal condition. The nervous system is an automatic governor regulating the blood pressure, secretions and nutrition of the entire body.

It is only now being recognized that *every* centrifugal nerve is concerned in the nutrition of the organs to which it passes. Section of a nerve causes the atrophy or degeneration of the tissues supplied by it. The wonderful effect which nervous processes may have on the growth, development or decay of the body are not yet appreciated. It is entirely scientific to suggest that a state of mind could produce a poison within the system capable of engendering severe disease, or, on the contrary, a secretion capable of affording immunity against contagious disease. In fact recent studies in the treatment of cholera and other germ diseases are bringing to light unsuspectedly close relations between the nervous processes and immunity. It has been discovered that epilepsy (apparently a purely nervous affection) may be produced by innoculation and may be fortified against, if not even cured, by the innoculation of suitably prepared lymph. It is another remarkable fact that, in such susceptible animals as the guinea pig, section of the principal (sciatic) nerve of the leg will produce modifications of the tissue of the neck forming epileptogene zones which upon irritation give rise to all the symptoms of epilepsy. While this process is not understood, it might be suggested that the nutritive disorders resulting from the section of a large nerve may produce morbid substances in the lymph which would react on the proliferating (lymphatic) centres giving rise to a pathogenetic lymph which would affect the nerve centres.

Such a speculation as this is indulged in simply to show how closely the nervous and vital processes are associated. The remarkable accuracy with which a lost limb will be restored after amputation in many amphibians might be appealed to in the same way.

Although there may still exist scholastics so blind to the discoveries of the last decades as to scout the interdependence of mind and brain, a little study reveals marvelous adjustments of bodily functions rivaling the most recondite psychical coördinations.

A question which has frequently been propounded to the writer is this: Does the brain continue to grow and elaborate cells and fibres after reaching maturity, and, if so, can the individual in any way influence or determine the nature and rate of such growth?

This is undoubtedly a question of serious import, not only to the surgeon but to educators and psychologists as well; and, while it is as yet impossible to answer it with as much confidence as could be desired, it may not be amiss to indicate the direction from which the solution may be expected and a few facts and suggestions looking toward that end. Corollaries of the question stated above give rise to the interesting problems respecting the phenomena of senility and decline as well as the physical reasons for the decreasing plasticity and educability of maturity. Much effort has of late been expended in the attempt to demonstrate in the tissues at large processes of senile degeneration—changes in structure corresponding to the limitations in function which experience associates with the process of growing old. These investigations appear to have yielded results disappointingly small. It would be natural to limit the search specifically to the central nervous system which, as has been seen, exercises a control not merely upon the function but concomitantly upon the growth of the bodily organ.

Recalling that the origin of all nerve cells is primarily from a proliferating epithelium it would be natural to expect that there should be a longer or shorter period of such cell-multiplication after which the wear and tear of nervous activity might gradually increase over the process of multiplication; for we must assume that nerve cells, like all other active tissue elements, wear out in activity.

The writer has given some time to the study of this question and finds evidence that certain portions of the proliferating epithelium persist to a very late period and continue the process of cell-formation. In other words centres are established whence are derived fresh cells to supply the place of such as become vitiated or depauperate.

It is a problem of great moment to determine how long and to what extent this process may continue, and what conditions may accelerate or retard the proliferation of new nerve cells.

There is probably no morphological study more fascinating and suggestive than the tracing of the marvelously intricate foldings and plications and invaginations and local thickenings which transform the embryonic nerve tube into the complicated structure known as the brain; but hand in hand with this study and of vastly greater practical import is the tracing of the development, migrations, and successive modifications of the cells which, although they all originate from the ventricular aspect of the tube, weave themselves into the intricate fabric of the brain.

In particular we may refer to the cerebellum as an organ quite devoid of psychical significance but profoundly important as the great supplementary reservoir of nervous energy which backs up the feeble mandates of the will by the sanctions of explosive nerve matter sufficient to wing the arrow of a Tell or guide the sling of a David.

The cerebellum, although an apparently massive organ second in size among the major divisions of the brain, nevertheless is proven to derive its peripherally distributed cells (which form its essential elements) from the proliferating cells of the ventricular epithelium.[1]

In lower animals, at least, the migrations of cells to reach their definitive station is facilitated by transitory folds which are subsequently obliterated by adhesion. In the same way masses of proliferating cells are apparently transported into the very midst of massive portions of these centres. Neglecting details then, the growing brain is supplied with factories for the production of nerve cells which may continue in operation a longer or shorter time according to circumstances.

Closely connected with the problem of origin is that of subsequent nutrition of nervous structures. While in some cases the branching protoplasmic process of nerve cells may be traced to the immediate vicinity of blood vessels, it is doubtful whether their purpose is the collection of nutriment, while it is certain that some cells must be dependent on other sources of supply.

It is probable that the lymph which is continually oozing through the pulpy tissue of the brain may have much to do with these processes. Still there is evidence that certain cells which arise in common with nerve cells and may be transformed into them have a temporary or permanent function of elaborating nervous substance for the active brain cells. Analogies are not wanting for this process. It is suggestive that, in those regions where very sudden and powerful discharge is required, these small cells are extraordinarily numerous. Thus, in the cerebellum, to every functional (Purkinje) cell there are hundreds of the corpuscles which possess almost no protoplasm of their own.

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[1] This statement, first made by the writer, has recently received the powerful support of Professor Wilhelm His, of Leipzig.

Enough has been said to show that there are great vital problems to be solved before the real significance of the essential organs of the nervous system can be made out.

Now if the period of cell formation is at all dependent on nutritive conditions we have a physiological explanation of certain very important facts in education. It is well known that exercise of brain functions promotes the flow of blood to the organ. Such an increase in blood will serve to modify the structure; it will also stimulate the proliferation of new cells. It is entirely rational to claim that an overdraft on this proliferating power may permanently limit the sources from which the nervous supply must subsequently be developed.

A recent paper in the *Hospital Gazette* by J. A. Diggle, M. D. gives concrete illustrations of this tendency. On the other hand, such moderate activity of mind as shall keep the centres nourished is essential to the normal cell-multiplication necessary to the development of the organs. It is an interesting problem also to trace the relation between such centres of multiplication and the processes of senility. Wilks has said "a man is no younger than his arteries." It is true that the sclerosed arteries, by being less elastic, and as a result of the disappearance of their muscles, become subject to hemorrhage which in the brain, at least, is soon fatal; but, as recently shown by Dr. Grube, "the senile condition is essentially a general atrophy." Inasmuch as atrophies are known to result from imperfect innervation, it does not seem far-fetched to claim that the source of senile degenerations may arise from the diminution of nervous power which, in turn, may be dependent on the exhaustion of the proliferating centres of cell formation within the brain. It becomes, therefore, a practical problem to discover what the conditions of senility within the brain really are and to what extent suitable stimuli (forms of exercise, etc.) may be employed to prolong the period of nerve making, and what activities and what sorts of stimuli may unduly or precociously excite and exhaust such centres.

There is some evidence that the brain continues to increase in weight up to the thirtieth (females) or fortieth year (males) yet there is as yet no adequate evidences as to the nature or conditions of the process. There is here a most fascinating and promising field for the physiologist.

These few suggestions may serve to illustrate the purely physiological aspects of neurology. They will sufficiently substantiate its claim to have a footing in practical affairs.

While we have noted the delicate balance of circulatory phenomena and nerve force and the control of the former by the latter there is another aspect which appeals to the psychologist. It is a familiar fact that when the blood pressure of an organ is disturbed, as when a foot becomes "asleep," curious and pronounced though vaguely localized *sensations* result. It is no less true that the changes in blood pressure due to psychical reflexes have such accompaniments. The "sinking at the heart," tingling at the extremities, peculiar twinge in the axils, and the indescribable "gone" sensation in the abdomen due to the shock of a sudden report, or a concept of a certain event, or the sight or odor of blood are instances of sensation no less powerful because vaguely localized. Just *because* they are unlocalized they associate themselves with our empirical ego and become the sensationial element in *emotions*. It is hardly too much to say that every emotion has some sensational element bound up with it. Elimination of the latter, when possible, leaves us a residuum somewhat different from the emotion. In the study of these organic sensations we doubtless have hope of a clue to the elimination of one of the least satisfactory sections of modern psychology. If it shall be shown that, exclusive of the sensational element alluded to, the emotions are characterized by judgments (explicate, or more frequently implicate) or intellectual processes so abbreviated and condensed as to resemble intuitions, one source of misunderstanding is removed.

We may conclude with a few concrete illustrations of the processes of proliferation mentioned above. [1]

The neuroblasts, or future nerve cells, which at first lie in oval interspaces between the bases of the epithelium cells or spongioblasts, soon begin to divide very rapidly, during which process the most beautiful spindle-figures are formed. The chromatin or idioplastic part of the nucleus, which at first was in the form of a loose reticulum, becomes a regular skein and then divides into two bands arranged in opposing nodes in the two halves of the nucleus, in short, the whole process of karyokinesis is beautifully illustrated and results in two new nerve cells. Thus are formed the two bulging masses of cells of the first embryonic vesicle out of which the corpora striata are produced, and in this way are formed the materials out of which the cerebellum, optic lobes, thalamus, and other regions of the brain are formed. As one follows, step by step, the multiplication, migration and subsequent modification of these cells, he cannot resist the desire to stimulate or retard the apparently simple processes upon which, however, the future of the animal depends, or at least to speculate upon the causes which determine the period at which this proliferation of nerve cells ceases in one area or region while it still continues in other.

In a very young salamander the brain resembles that of an adult fish in the fact that the cortical part of the cerebrum is only represented by a single layer of epithelium. In the

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[1] What follows was not printed in the "Quarterly."

amphibia, however, this stage is transitory and the "pallium," which remains throughout life the only representive of the cortex in fishes, is in, the Salamander, quickly folded into the interior and encroached upon by excursions of cells from the striatum or proliferations from the stray neuroblasts in its own substance.

It is remarkable how differently the several parts of the brain behave with reference to the development of the nerve cells. The medulla, which is charged with the control of the vital functions, has exhausted its power of cell-multiplication from the primitive neuroblasts long before the archetecture of the cerebellum is nearly finished. We cannot resist the belief that there are extensive migrations of the growing nerve cells during the earlier development periods. The appearance of the embryonic brain of a frog, for example, is almost impossible to explain except upon the theory that, not only are the nerve cells actively sprouting forth nerve fibrils which find their way to distant regions of the brain with an instinct as infallible as that of a plant shoot for light, but cells are actually moving from point to point in the intervals between the rapidly elongating epithelium cells leaving a thread behind, as a spider might in its passage. Such a migration toward the periphery has been described by His in the cord and we have followed even more extensive migrations in the cerebrum. Thus cells which arise from the epithelium reach the external part of the brain and turn transversely (in amphibia) and send long processes to subdivide in the brain base (*pes pedunculi*) where they indirectly communicate with the cerebellum.

As already stated, the process of cell-multiplication is completed much earlier in some regions than in others. Thus, in fishes, after the process is practically somplete elsewhere, it continues very actively in an accessory structure of the cerebellum known as the "volvula." The organ referred to is peculiar to fishes and its late development seems to indicate that this structure is a late acquisition phylogenetically and this possibly indicates that the group of fishes is a late off-shoot of more typical earlier (amphibian-like) progenitors. Ascending the scale, we find that the greater complexity of brain structure and (by corollary) more extended development period introduced difficulties in the way of carrying out of the simple plan of migration of cells from the neuroblasts arising near the ventricle. That such is their ultimate source cannot be doubted, but secondary proliferating centres are necessary to adequately supply with nerve cells those brain-areas which, as a result of the remarkable folds of the originally simple brain tube come to occupy regions far removed from the ventricle. Professor His has shown that the olives and many other structures of the medulla are formed by the separation of the neuroblast cells from the ventricle and their transferrence by means of folds and concretion of brain substance to regions far removed from their source. The writer has applied the same principle to the problem of cell-formation in the cerebellum of certain mammals. It is also easily observed in the development in the fish brain of the hypoaria and nidulusniger. In the cerebrum of mammals there is a curious temporary proliferating belt at the surface which persists up to a comparatively late period of embryonic life.

It may be noticed that, although the active stage of embryonic cell-proliferation is, in general, limited to a period more or less narrowly restricted, it does not by any means follow that all the cells thus formed at once become functional. In certain brain regions vast accumulations of granules are formed which are essentially dormant nuclei with the smallest possible amount of protoplasm. Such nuclei are especially abundant in the cerebellum, optic tectum, corpora striata and olfactory lobe, or, in general, in regions in which there is rapid destruction of nervous matter or activity is partially dormant. Such nuclei are variously interpreted, but recent studies have convinced the author that many of them are simply dormant nerve cells which may become functional at a later period. In the tectum opticum, for example, the transition between the granules and functional ganglion cells is complete. It has also been shown that, of the vast number of granules in the inner layer of the cerebellum, many at least are of a nervous character and possess a certain amount of protoplasm with the usual processes. Mr. Turner and the writer have suggested that the rosette clusters of cells in the axial lobe of reptiles and birds may also be of the nature of proliferating centres.

From the anatomical standpoint, therefore, it is reasonable to admit the hypothesis that, although the number of brain cells is to a certain extent predetermined and they are separately outlined in an early stage, yet they do not become functional until exigencies require it and the period and rate of becoming functional may depend largely upon such matters as nutrition, mental exercise, etc. It seems probable that these newer cells are at first to a certain ex-extent indifferent in function and that, by the interpenetration of their terininal brushes with the reticulum formed by "dentrites" of other cells, they come to participate in the general functions of the reticulum and the elements of which it is formed. Such cells might easily substitute for other cells that had been injured or removed by accident or worn out by use. Nevertheless it seems improbable that a complete renewal of cells takes place, for, in that case, the physical basis of memory would remain quite as obscure as it has hitherto seemed. It is true that almost the only hints we have respecting the physical basis of memory are such as grow out of the known connection between cell-reproduction and the chromatin and other elements of the nucleus and suggestive resemblances between memory and heredity. For the present it is perhaps quite as satisfactory to admit that a physical apparatus for memory remains to be discovered.

METAMERISM OF THE VERTEBRATE HEAD.

[Collated for this Journal.]

The following notes are, for the most part, derived from the report presented by Professor Rabl and others at the sixth annual meeting of the German Anatomical Association held in Vienna, June, 1892. Passing over the vertebral theory of the skull which, from the time of its founding by Goethe and Oken and its amplification by Owen, flourished uninteruptedly up to 1886, we find a modern point of view maintained by Huxley, who showed that no part of the bony skull can be regarded as a modification of primitive vertebrae. Huxley called attention to the fact that all organs of the head must be considered in seeking the genesis of the latter. Especially significant are the nerves and their derivatives, particularly their relations to the gill clefts. The olfactory and optic nerves are not included among cranial nerves proper but are diverticles of the brain. The first gill cleft is innervated by the glossopharyngeal, while those following are supplied by vagus branches. From the trigeminus is derived a superior maxillary and inferior maxillary division which are related to the mouth as the preceeding are to the gill clefts. The trabs and palatal process of the maxillary were regarded as pre-oral visceral arches. Huxley, therefore, still clung to a belief in a definite segmentation of the head.

Gegenbaur in 1871–72 came to analogous conclusions from his study of *Hexanthus*. He states that the cranium is comparable to a portion of the spinal column which has at least as many vertebra-like segments as there are gill-arches. The number of vertebæ must have been as many as nine, possibly more.

1st arch. First upper labial cartilage	Ramus secundus	trigeminus.
2d arch. Labial cartilage arch	Ramus tertius of	
3d arch. jaw	Facial.	
4th arch. hyoid	Glossopharyngeal.	
5th arch. 1st gill	Ramus branchialis 1	Vagus.
6th arch. 2d gill	Ramus branchialis 2	
7th arch. 3d gill	Ramus branchialis 3	
8th arch. 4th gill	Ramus branchialis 4	
9th arch. 5th gill		

The first to seriously study this question from the embryological point of view was Balfour. He adopted Gegenbaur's views respecting the post-auditory segments but postulated other primitive nerves which have since disappeared. The facial and auditory are embryologically united, while the former is obviously the hyoid nerve. The trigeminus is similar to the facial, the R. opthalamus profundus being a ramus dorsalis, the R. maxillaris inferior corresponds to the main trunk, and the R. maxillaris superior is a ramus præbranchialis (corresponding to buccalis of the 7th.)

Segments,	*Nerves,*	*Arches,*	*Head cavities,*
Preoral 1.	3d 4th and (?) 6th	?	1st head-cavity
Postoral 2.	5th nerve	mandiblar	2d head-cavity
Postoral 3.	7th nerve	hyoid	3d head-cavity
Postoral 4.	9th nerve	1st gill arch	4th head-cavity
Postoral 5.	1st branch x	2d gill arch	5th head-cavity
Postoral 6.	2d branch x	3d gill arch	6th head-cavity
Postoral 7.	3d branch x	4th gill arch	7th head-cavith
Postoral 8.	4th branch x	5th gill arch	8th head-cavity

Subsequently Marshall sought to include the olfactory as a true cranial nerve and homologized the nasal sac with a gill cleft. Marshall also observed the segmentation of the brain tube and attempted to discover a cranial nerve for each expansion of the tube.

In 1882 he published the following table:

Segment.	*Nerve.*	*Visceral cleft.*	*Visceral arch.*
1	Olfactory	Olfactory	
2	Oculo-motor Trochlearis	Lachrymal	Maxillary
3	Trigeminal	Buccal	Mandibular
4	Facial Abducent	Spiracular	Hyoid
5	Glossopharyngeal	1st branchial	1st branchial
6	Vagus 1st branch	2d branchial	2d branchial
7	Vagus 2d branch	3d branchial	3d branchial
8	Vagus 3d branch	4th branchial	4th branchial
9	Vagus 4th branch	5th branchial	5th branchial
10	Vagus 5th branch	6th branchial	6th branchial
11	Vagus 6th branch	7th branchial	

Van Wijhe about the same time published investigations on the selachian head.

Nine mesoderm segments were identified, three of which lie cephalad of the ear capsule. The several somites subdivide into a myotom and sclerotom but vary greatly in subsequent modifications. From the walls of the first myotom are formed those eye-muscles which are innervated from the oculo-motor while the muscle supplied by the trochlearis (oblig. sup.) is formed from the walls of the second myotom and the rectus externus from the third myotom. The fourth and fifth myotoms disappear.

Each nerve to a visceral arch originates as a dorsal root and divides into a ramus dorsalis and a ramus ventralis, both of which may possess a ganglion. The ramus ventralis forms two principal branches, the ramus posttrematicus and ramus pharyngeus, which latter forms a ramus prætrematicus.

Alborn (in his work—Ueber die Segmentation des Wirbelthier Körpers, 1884.) concludes that mesomerism (segmentation of mesoderm) stands in no necessary connection with branchiomerism (segmentation of entoderm, i.e. gill clefts.) In so far as the distribution of nerves is influenced by the latter it does not conform to true (mesomeric) segmentation. Neuromerism is secondary—conditioned by mesomerism.

Froriep found special dorsal branches of the hypoglossus and considers this nerve distinct from the vagus and composed of several cranial nerves while the vagus is a complex of segmental cranial nerves. The occipital region should be morphologically included with the spinal cord. Froriep also announced that ganglia on the facial, glosso-pharyngeal and vagus are connected with the skin. [1]

These points are anlags of sensory organs analogous with the organs of the lateral line, but never attain functional development. Baird's paper on the same subject was adequately re reviewed in the paper above referred to, in volume I. The views of Weidersheim are similar to those of Baird and are expressed in the familiar diagram in his Comparative Anatomy.

Gegenbaur, in his paper entitled "Ueber die Metamerie des Kopfes und die Wirbeltheorie des Kopfskelettes," enters into an extensive criticism of previous authors. He considers Van Wijhe's head somites very dissimilar structures containing elements from the trunk. He does not accept the double nature of the hyoid arch. The 4th, 5th, and 6th segments are rudimentary. The 7th, 8th, and 9th are trunk segments. Gegenbaur does not accept the identification of the lense capsule, hypophysis, auditory vesicle, spiracle, etc., with gill clefts. He thinks there was originally complete concordance between branchiomerism and mesomerism, but that subsequently, by a disappearance of some branchial arches trunk segments are projected forward. Olfactories and optic are not included among segmental nerves. Admitting the possibility that the oculomotor may belong to Van Wijhe's first segment with the R. opthalamicus as dorsal root, he considers the first real metamer the second segment of Van Wijhe with the first gill arch. The trochlearis belongs to the former and the R. mandibularis trig. to the latter. The second metamer consists dorsally of the third and part of the fourth somite and ventrally of the second gill arch and has the abducens and acustico-facial nerves.

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[1] Refer to paper by Prof. Kupffer in vol. I., October and December, 1891.

The vagus is polymerous and its ventral roots are ventral roots of the spinal nerves amalgamated with the head. The prechordal part of the skull is non-vertebral. The visceral arches are regarded homodynamous with ribs.

Dohrn, by reason of the large number of myotoms which he identifies, regards nasal sac, lense, hypophysis, mouth, thyroid, auditory sac, etc., as modified gill-clefts. In view of the fact that VanWihje finds 4 segments in the anterior head region and Dohrn 12-15, one is relieved to agree with Rabl that there is no mesodermal segmentation of this region. He requires that a primitive segment should form a part of the dorsal (and only the dorsal) mesoderm and that it divide into (muscular) myotom and (osseous) sclerotom portions.

In the Verhandlungen der Anatomischen Gesellschaft, June, 1892, (appearing as Ergänzungsheft des Anatomischen Anzeigers), Professor Froriep describes anew the so-called neuromers which he had observed in mole embryos, but concludes that they are of no special morphological significance. He also concludes that the so-called primary neuromers detected by Kupffer in Triton embryos are simply the results of underlying mesoderm-somites.

In the same publication Professor Hatchek discusses metamerism in Amphioxus and Ammocetes. The brain of Amphioxus is, in the embryo, a cephalic enlargement of the medullary tube larger than the cord and consists of three cavities, of which the first is the primary prosencephalon. From the base of this vesicle the cavity (infundibulum) is extended to connect with the ciliated sac, to which the olfactory also passes.

The second portion (mesencephalon) has a narrowed cavity. The third (metencephalon) has a characteristic dorsal expansion or fossa rhomboidalis.

The ciliated sac corresponds to hypophysis and olfactory organ of Craniata. In Ammocetes the external opening of the hypophysis is still dorsal and is connected with the olfactory.

The dorsal root of the spinal nerves, which has no connection with the ventral, passes directly to the inner skin, there dividing into a dorsal and ventral branch. Small clusters of ganglion cells occur, especially at the point of bifurcation. The whole length of the nerve from cord to skin is to be regarded as homologous with a sensory root, while the ganglion lies upon the skin in immediate vicinity to its point of origin The dorsal ramus gives off a N. cutaneus dorsalis and a N. lateralis dorsalis and the ventral ramus forms a N. cutaneus ventralis and also a N. visceralis. The ventral root is the special nerve of the body muscles.

The mouth in Amphioxus is not produced from a gill cleft; one such cleft (ciliated sac) lies in front and another (pseudobranchium) behind, forming 14 in all. The first cleft lies on the caudal margin of the first metamer and all are inter segmental.

From a study of *Ammocetes*, the author concludes that none of the postoral myomers disappear (contra Kupffer.)

The rectus externus corresponds to a prootic myomer. The obliquus superior is a branch of the pharyngeal velum (corresponding to the abductor of the mandiblar arch.) The other eye muscles were not satisfactorily construed but are probably derived from the constrictors of the visceral apparatus.

The trigeminus corresponds to two nerves and contains (1). the frontalis primum (lateralis dorsalis); (2), portio profunda of ophthalamicus (lateralis dorsalis); (3), man dibularis (ramus ventralis.)

The maxillary undoubtedly corresponds to a R. ventralis and belongs to "trigeminus A," while the mandibularis corresponds to the ventral ramus of "trigeminus B."

The ramus ventralis, which springs from the caudal portion of the facial ganglion, is the nerve of the pseudo branchial groove and the hyomandibularis is its posttrematic branch, while a branch corresponding to a pretrematic gives off a branch to Kupffer's organ.

The acusticus is a N. lateralis dorsalis and the inner ear corresponds to an organ of the lateral line.

A primary vagus, supplying a single segment is distinguished from five ventral ganglia of succeeding segments.

The oculomotor is a derivative of the visceral rami of the trigeminus A and the trochlearis of trigeminus B. The abducens is the first ventral root belonging to the facial. In the main, therefore, Hatschek agrees with Gegenbaur.

		Seg-ment	*Myotom.*	*Ventral Roots.*	*Dorsal Roots.*	*Visceral Arches Epibranchial Sense Organs.*
Prootic Metamers.	Fore-head.	I	(a) "Medullary" region, Olfactory and nose (The 1st a "medullary" nerve related to a "neuroporus" sense organ. Optic and retina (the 1st an "intra medullary" nerve related to a "medullary" sense epithelium.) (b) Dorsal nerve roots situated cephalad of the first myotom.			
			Myotom absent.	Absent.	Trigeminus A*, situated cephalad the first (reduced) myotom, later: Oculomotor, as derivative of the visceral branch of the above.	Visceral cleft absent. Anterior organ of the ventral lateral-line (?)
			(c) Normal Metameric portion.			
			Myotom reduced.	Reduced.	Trigeminus B†, situated candad of first (reduced) myotom later. Trochlearis, as derivative of the visceral branch of the above.	Mandibular visceral cleft (rudementary.) Mandibular arch, First epibranchial sense organ
		II	Musculius lateralis.	N. Abducens.	Facial, including auditory (as nerve of a dorsolateral sense organ.)	Pseudobranchial border (=Hyoid cleft.) Hyoid arch (behind auditory capsule.) Second epibranchial sense organ.
Metaotic metamers.	Primitive hind-head region.	III	1st Metaotic myotom.	Ventral root of glossopharyngeal.	Glossopharyngeal.	1st true visceral cleft. 1st visceral arch. 2nd epibranchial sense organ.
		IV	2d Metaotic myotom.	Ventral root of vagus.	Vagus and the dorsal ganglionic portion, including the 1st ventral (epibranchial) ganglionic mass with its peripheral nerves.	2nd true visceral cleft. 2nd visceral arch. 4th epibranchial sense organ.
	Hind gill region.	V to IX	2d Metaotic myotom, etc.	Ventral roots of the spinal-like (spinal artigen) nerves.	Spinal-like vagus branch and the following spinal-like nerves. 2nd—6th ventral (epibranchial) ganglia of vagus.	3rd—7th true visceral clefts. Visceral arches. Epibranchial sense organs.

Segmentation of back follows.

*Trigeminus A includes: N frontalis primus; Portio profundus of Opthalmic; N. Mandibularis.

†Trigeminus B includes: N. frontalis primus; Portio superficialis of Opthalmic; N Mandibularis.

ADDITIONAL PSYCHOLOGICAL NOTE UPON THE GALLERY SPIDER.

By C. H. Turner.

Example XXXV, E.—After my last paper had been printed, this spider made a unique addition to its web. At a height of about five inches above the main sheet of the web [see Ex. XXXV, D, supra. p. 107], the spider constructed a funnel-shaped web. The circumference of this web was attached to the sides of the jar and the apex was directed downwards. In form this accessory web was a true cone. It was a sort of pyramid-shaped body, composed of several unequal flat surfaces. It was fastened to the lower web by tension cords. Its apex was about an inch above the lower web. Snares were abundant, but there was no gallery. This addition to the web converted it into a miniature model of a lobster-pot. The spider usually rested in the gallery of the lower sheet. Every fly that fell upon this upper sheet was doomed to die. Every struggle carried it nearer the apex of the funnel. Sooner or later, it was sure to fall into the trap below. There it was at the mercy of the spider.

There was no obstructions to prevent the flies escaping by the same opening which they entered; but I have observed numerous flies tumble into the web and not one thought of escaping by that opening. Whenever a fly was so fortunate as to become disentangled from the lower sheet before being captured by the spider, it was sure to make for the highest portion of the trap. There, hemmed in by the web on all sides, it became an easy victim.

There is another point I wish to add here. In many of the webs constructed by my imprisoned spiders, the gallery had two openings. One of these openings led on to the main sheet, while the other led to the sand below.

For a long time I was at a loss to know what the spiders did with the remains of the dead flies. Although the spiders captured a number of flies, yet the webs seldom contained more than one or two flies; and sometimes the webs were entirely empty. One morning I saw a spider carry a fly down the gallery and drop it on the sand below. This led me to examine the sand in all my arachnaria. Upon the sand I found the remains of a large number of flies. Although I did not observe my spiders take but one fly and place it on the sand, yet the facts seem to warrant the conclusion that the spiders remove dead bodies from their webs. I do not, however, believe that the observed facts warrant the conclusion that they are always conveyed down the gallery. Indeed the location of many of the flies seemed to indicate that they had been carried to the edge of the web and dropped over.

INTELLIGENCE IN ANIMALS.

I.

A CASE OF ABSENT-MINDEDNESS. A tame raccoon, which has been observed for some time, still has the habit of washing its food. On several occasions food was given him when hungry, in such small morsels that on the way to his water pan he devoured it completely. He continued toward the pan and assumed the customary position before observing that he no longer had anything to wash This was repeated several times until he seemed at last to "recollect himself," as we say, and the small fragments were no longer carried toward the water. This simple and probably familiar observation indicates a similarity between instinctive and habitual processes of some interest in forming opinions upon instinct.

II.

LOGICAL INFERENCE IN A DOG. The following incident related by T. H. Pritchard, was kindly communicated by Professor G. W. Manly. From a personal letter to the latter we are permitted to quote as follows :

"WILMINGTON, N. C., July 22, 1892.

PROF. G. W. MANLY : The facts about the dog are the following : Some fifteen years ago I was hunting in Wake Co., N. C., *with a handsome young pointer dog*, called Dr. Pritchard, as I had given him when a puppy, to President F. P. Hobgood, and he had named him after me, with my consent. This dog was sent to me from Salisbury, by my kinsman, Baldy Boyden, and was said to have been of excellent stock. I do not think he was more than two and a half years old at the time the incident occurred which I am about to relate.

The dog leaped on the fence, not having smelt birds before; for a time he remained stationary; I saw him and knew that he was standing birds. After a little while he carefully crawled down on the same side of the fence from which he had approached it, and then went down the fence some forty or fifty yards, leaped the fence, cautiously approached the covey from the other side and when he got at the proper distance, stood them as usual. I have often instanced this case as demonstrating the power of legitimate, logical reasoning in a dog. As a mental process I believe it was as clear a case of reasoning as was ever done by Sir Isaac Newton. He knew that if he jumped over the fence, they were so near that they would fly, which was a thing he must by all means avoid; so, after turning the matter over in his mind, whatever sort of mind it was with which he was endowed, he concluded that he could reach them by going down the fence and coming up on the other side.

When this dog died his obituary was published in an Oxford paper. In that obituary he was spoken of as President Hobgood's faithful friend, Dr. Pritchard, and many persons thought it was I that was dead."

AN ILLUSTRATION OF THE TAXONOMIC APPLICATION OF BRAIN MEASUREMENT.—FULICA.

By E. G. STANLEY.

To illustrate the way in which the present system of bird classification is looked on by ornithologists, we quote from the Encyclopaedia Britannica, Ninth Edition, Vol. III, p. 699:

"The difficulty of applying this very valuable morphological grouping [Professor Huxley's], and making it fit with one that is more general and distinctively zoological (that is, having reference to every character, external and internal), does not take away anything of real value from it. To the anatomist, such a mode of viewing the various types is perfectly natural, however hard it may be to satisfy the pure zoologist as to its great value. Certainly, the structure of the skull and face govern the whole body, as it were; every other part of the organism corresponds to what is observable there. Nor must it be forgotten that the true mode of studying any kind of creature is that of its *development*, and the head undergoes the most remarkable morphological changes." And again, after giving an outline of the system:—"The above scheme is a nail in a sure place, and in it, for the present, we may hang all that we know, or are learning, of the anatomical structure of this class of vertebrates. That which relates to the *Carinatæ* must, however, be regarded merely as a *list* of Birds having a simiiar facial structure." When we reflect that the *Carinatæ* include nearly all of our present birds, the last sentence is significant.

The illustration chosen, *Fulica americana*, may be considered a crucial test of the value of using the bulk of the prosencephalon as a criticism of classification, in that it combines the essential characteristics of the Alectorides (cranes, rails, etc.), with the external appearance and habits of the anserine birds (ducks, etc.). The coot, although possessing a bill and frontal plate like the gallinules, has the depressed body, thick under-plumage and natatorial feet of the duck: it is eminently aquatic, swimming by means of lobate, rather than webbed feet.

Were it assumed that the proportions of the brain are conditioned by the size and habits of the bird, we should expect close agreement in brain measurement between our species and the duck. On the other hand if the proportionate of the brain is determined by phylogeny, we should rather expect agreement with those groups with which *Fulica* is morphologically alied The consensus of orinthologists associates this form with the rails, and thus with the cranes and herons. A comparison of the measurements appended show that, in accordance with the scheme proposed by Mr. C. H. Turner, in this *Journal*, Vol. I, page 39, the place of *Fulica* in the scale is a little above the duck, still more above the domestic fowl, ranking between the *Limicolidæ* and the *Herodiones*.

The measurement given in each case is the ratio of the actual measurement of the part to the entire length of the brain expressed in hundredths. The symbol $\sqrt[3]{\text{L. B. D.}}$ indicates the cube root of the product of the length, breadth, and depth of the prosencephalon, thus giving us the means of comparing the bulk of that important part of the brain in different birds. In *Fulica* the dimensions expressed above are: for the rhinencephalon, length, 14.2; breadth, 18; the lobes project and are not fused: prosencephalon, length, 73; breadth, 90; depth, 55; $\sqrt[3]{\text{L. B. D.}}$ 71.22; mesencephalon, length, 27; breadth, 22; epencephalon, length, 50; breadth, 33; depth, 38; metencephalon, length, 40; breadth, 33; depth, 22; length of brain, 22 m m. In the duck we find, for the rhinencephalon, length, 16; breadth, 13; prosencephalon, length, 74; breadth, 87; depth, 54; $\sqrt[3]{\text{L. B. D}}$ 69.3; mesencephalon, length, 33; breadth, 23; epencephalon, length, 26; breadth, 33; depth, 43; metencephalon, length, 50; breadth, 33; depth, 30; length of brain, 33 m.m. In *Gallinago wilsoni*, $\sqrt[3]{\text{L. B. D.}}$ is 75.18, while in *Ardea herodias*, it is 58.43, showing how far our species (*Fulica*, 71.22) is above the herons.

EMBRYOLOGICAL NOTES ON THE BRAIN OF THE SNAKE.

C. L. HERRICK.

With Plates XV–XIX.

A few isolated memoranda from a larger number gathered during the present year, are here presented, with especial reference to certain morphological problems.

GENERAL DESCRIPTION. The embryos in question represent three stages from *Eutænia* and one from the black snake, the latter being a little older than the oldest garter-snake embryo. The youngest embryo is somewhat less mature than the youngest figured by Rathke.[1]

Rathke's embryo possessed but two pairs of gill clefts while

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[1] RATHKE, H. Entwicklungsgeschicte der Natter, 1839. Plate I, Figs. 1-5.

ours had three perforate and one cleft which may not have been perforate. This stage was secured in Granville, O., June 9th. Plate XVI, Fig 1, shows the general appearance while Fig. 2 is an enlarged drawing of the head (camera outline.) The eye is in a primitive condition, the lense capsule still cohering with the skin and unclosed. The cervical flexure is more than 45 degrees, the mesencephalic flexure more than 90 degrees. The diencephalon is still much longer and larger than the primary prosencephalic vesicle. The nasal sacs have not yet formed and the olfactory epithelium is connected with the hypophysis anlag and lense capsule by a continuous band of sensory epithelium. The point on the ventral surface where the great mesencephalic flexure is pivoted is obviously the angle of the jaw, or the region of the hypophysis (pituitary.) Rathke is correct in saying that the latter body is not as yet formed, but its anlag as a thickened patch of epithelium is quite obvious. Plate XIX, Fig. 1, (207.5.) The recognition of the region of the hypophysis as the morphological front of the head serves to interpret for us several of the most difficult problems of comparative morphology. The morphological front of the brain is the region of the infundibulum, from which the true terma may be traced cephalo-dorsad. The diverticles beyond this point are all from the dorsal or dorso-lateral aspects of the brain. These may be counted as follows: recessus opticus, primary prosencephalic vesicle, dorsal sac, epiphysis, and roof of the thalamus proper. If this interpretation could be accepted, the præ-commissura, callossum, hippocampal commissure, habena and supra-commissures, are all analogous structures. The sensory epithelium of the forehead region gives rise to (1) hypophysis, (2) Jacobson-nasal structure, (3) lense capsule. It is possible that the latter belongs to the epidermal area corresponding to the mesencephalon and that it has been excentrically displaced by the rapid arching of the head. We would recognize the existence of a lateral sensory epithelium band which is strictly lateral in the post-cephalic regions and becomes symmetrically segmental forming the lateral line system. In the region of the gill clefts this system gives rise to the branchial sensory organs. Cephalad of this point the strong and irregular growth and flexures serve to disarrange the primitive simplicity of the epithelium. The ear-capsule, lense-capsule and sensory pits of the head (in fishes) are to be included. The strong confirmation which these views have recently received from the study of Amphioxus and Ammocetes is elsewhere referred to.

It will be noticed that the surface from the angle of the mouth to the nasal end of the head is nearly in one straight line.

The next stage is from embryos taken June 11th. Growth during this period is very rapid and in order to secure consecutive stages a large amount of material would be needed. The lense has closed and separated from the skin. The gill clefts have closed with the exception of a single pair. (The posterior pairs were not made out as distinct openings in any of the specimens examined.) The nasal sacs have been formed and extend from immediately cephalo-ventrad of the eye toward the cephalo-ventral aspect of the head. It can be readily seen that the growth is from ventro caudad cephalo-dorsad; i.e., that the epithelium is driven up into the pits by proliferation in that direction. In accordance with the suggestion just made, the growth is from the pituitary region caudad (morphologically) and, as in Amphioxus the nasal and pituitary structures are associated, so here at first the same relation prevails. It may also be noted that the protrusion of the recessus opticus and the infundibulum are causing the palatal area to be flexed. The whole cerebral part of the head is being flexed dorsad,—as may be seen by examining later stages. There is as yet no external evidence of trunk segmentation but the medulla is strongly segmented and produces a superficial node-like appearance behind the ear. (Plate XVI, Fig. 3.)

The third stage is represented by Eutænia embryos taken June 15th. The germinal disc covered three-fourths of the yolk and the tail described three turns. (Plate XVI, Figs. 4, 5.) The backward flexure of the front of the head is still more marked and the nasal sacs are carried cephalo-dorsad. The myomers of the trunk and tail are prominent.

In this stage the lense is beginning to fill out the capsule and the retina has stongly differentiated from the pigment layer, but the primary optic vesicle has not closed and the optic fibers have not begun to appear.

The pituitary is just forming and has not called out any responsive development in the infundibulum. The cephalic sensory epithelium remains as a continuous band along the palatal surfaces, but is thickened at the ridge bordering the mouth laterally, from which point it can be traced into the nasal epithelium.

The remaining embryos at our disposal are from a black snake killed July 19th. These seem to be relatively less developed than the last mentioned. (Plate XVI, Figs. 6, 7.) No special description is necessary as the differences are all such as may be explained as connected with the peculiarities of the type. The above embryos will be referred to as E. I, E. II, E. III, and C IV respectively.

THE DORSAL SENSORY PLATE.—In reptilian embryos of early stages the existence of a continuous sensory plate from the hypophysis (pituitary) to the auditory region is very obvious. In very early stages the front of the embryo coincides with the future infundibulum and the subsequent growth only increases the dorsal surfaces without adding anything to the ventral. The nasal sacs, lense capsule, and sensory epithelium of the gill-clefts is one continuous plate differing from the remainder of the ectoderm in its greater thickness and columnar character. The epithelium has the proliferating power so characteristic of the sensory epithelia and gives rise to its own ganglia and nerves. It would be natural to seek further homologies in the lateral line organs.

In embryos of Eutænia of the age figured (Plate XVI, Fig. 1,) the olfactory pits are not formed but the dorsal sensory plate is thickened cephalo-dorsad of the lense capsule. In Fig. 1, Plate XV, a portion of a section is shown which on the left side illustrates the formation of the lense capsule but this section does not show, what may be readily seen in others of the same brood but less advanced, that the lense-capsule epithelium is continuous with another portion of the sensory plate of the frontal region. Along the caudal regions this epithelium is continuous with a thin membranous portion with flat cells. Tracing this layer cephalad over the convexity of the primitive vesicle it shows a tendency to thicken and to invaginate until it fuses with the epithelium of the pituitary anlag. It seems to the writer that there is no reason to doubt the suggestion that the pituitary is that sensory invagination which is formed at the morphological front of the head. One cannot carefully trace the genesis of the brain and head in Ophidia without being convinced that this is the clue to the complicated problem of cephalogenesis. The query so often raised as to the reason for the restriction of the chorda to præ-infundibular regions of the head requires no further discussion if it is recognized that the pituitary marks the beginning of a dorsal surface and all structures in the skull arising cephalad of it cannot be considered as segmental in a strict sense. The stomatodeum is that portion of the ectoderm which has been phylogenetically interpolated between the primitive subterminal mouth and the present oral aperture. (See Plate XIX, Fig. 1.) The structure of epithelium and the origin of the neuroblasts within it at the ofactory area is well shown in plate XV, Fig. 8, the portion forming the lense and its capsule at plate XV, Fig. 7.

THE CRANIAL NERVES.—In E II, the trigeminal is already quite well developed. The vesicle is moderately expanded and upon its lateral aspects a small cluster of cells is seen which, however, does not directly communicate with the medulary wall itself. On the other hand, the connection is very direct and obvious with the seat on the ectoderm at the base of the mandibular anlag. The nerve at this stage has all the characteristics of a sensory nerve arising from a special centre in the skin.

In E. II, the three divisions are well distinguished. The ophthalmic extends only as far as to a point dorso-mesad of the eye, while the combined maxiliary and mandiblar rami extend latero-ventrad to the angle of the mouth, the former turning rapidly cephalo-laterad and reaching almost to the eye, while the later dips into the rapidly growing cells of the mandiblar anlag. The vesicle (caudad neuromer) is without an obvious nerve at this stage, although its neuromer is as large as any of the following ones. It would appear that its dorsal roots enter with the fifth. The seventh nerve passes directly cephalo-ventrad to the hyoid arch. It arises with the auditory. The motor cells lie on the ventro-lateral aspects but do not emerge there. The auditory ganglion arises from a special anlag formed with the capsule and for a long time does not communicate with the medulla.

Two roots arising from two neuromers caudad represent the ninth and tenth anlags, the former simply related to the gill cleft corresponding while the pneumogastric gives off branches to two and apparently three rudimentary clefts and also a vagus branch which passes along the mesoderm to the masses of cells in the vicinity of the future stomach. The neuromer lies immediately mesad of the auditory capsule.

In Eutænia III we note the existence of a peculiar elevated and modified area of the ectoderm which, although it might be regarded as accidental, is sufficiently remarkable to warrant description. It lies exactly over the site of the valvula cerebelli i.e. over the chiasm of the trochlearis. The area is quite conspicuous in longitudinal horizontal sections and is differentiated from the adjacent parts of the ectoderm by the commingling of peculiar nuclei with numerous deeply stained granules in a clear stroma (haematoxylin stain.) The cells are closely massed in a spheroidal body. As the sections penetrate deeper the deeply colored granules accumulate and the large epidermal cells become fewer. There is an appearance of rapid degeneration. The nuclei containing the granules vary greatly in size as well as in the size and number of the granules. There seems to be some ill-defined connection with the brain tube at the valve, but nothing very definite was observed. The observation is recorded with a view to direct attention to the possible existence of a dorsal sensory organ correponding to the trochlearis or isthmus segment. On the other hand, it must be observed that nothing similar has been seen in younger Eutænia embryos or in those of the black snake.

In E. III the third (oculo-motor) nerve arises from the very distinctly expanded base of the mesencephalon just cephalad of the isthmus. The cells which give rise to the fibers are formed from neuroblasts from a sharply localized area and the fibers pass out directly. It seems to me that the nerve is continually replenished by neuroblasts which pass out along the roots and add to the originally small number of cells lying in the course of the nerve. These neuroblasts evidently fuse with their predecessors in such a way that, as each neuroblast acquires a sheath, these successive portions form the Ranvier segments of the sheath of Schwann. This seems to be the uniform method of development whether within or outside of the central organ. The third nerve fibers pass ventro-cephalad and cross the ophthalamic which becomes smaller and loses itself near the meso-cephalic aspect of the eye. The oculo-motor terminates near disperse clusters of indifferent (muscle) cells caudad of the eye anlag.

In E. II the oculo-motor nerve was not recognized, though probably about forming.

In E. II the relation of the various clefts of the visceral region is especially well shown. The hypophysis is a simple pouch-like diverticle and is in communication cephalad with the mouth cleft and caudad with the eustachian tubes diverticles of the second branchial cleft. These have already begun to assume a tubular form. The preceding clefts are imperforate, the second being represented by ectodermal and entodermal pouches which do not meet,

NEUROMERS IN THE OPHIDIAN EMBRYO. Waters has given a brief summary of the history of opinion respecting the expansions of the medullary tube which have been noticed by most embryologists since VonBaer.[1] To this paper the reader is referred for bibliography.

Balfour recognized the possibility that these "earlier constrictions may potentially correspond to so many nerve roots.

BERANECK[2] in several papers attributes segmental value to these dilations, as did Kuppfer.

Orr, in studying these expansions, decides (1) that successive neuromers are separated by external dorso-ventral internal ridges, (2) that the neuromeric constrictions are symmetrical and opposite, (3) that there is a radial arrangement of cells within each neuromer, (4) that the cells are confined to their respective neuromers, there being a shape line of demarkation, (5) that the nerve roots arise from the crests of each neuromer. The first [hind brain] neuromer gives off the trigemenal, the second the abducens, the third the seventh and eighth, etc., (6) that the mid-brain is not segmented while the fore-brain has two neurom-

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[1] WATERS B. H. Primitive segmentation of the Vertebrate Brain. *Quarterly Journal of Microscopical Science.* June, 1892.

[2] Recherches sur le developpement des nerfs craniaux chez les lezards. *Recueil Zool. Suisse.* 1887, and Replis medullaires du Poulet. ibidem.

ers, and (7) that the cord is not segmented. McClure demonstrated neuromeric segmentation throughout the cord but does not agree with Orr as to the sixth nerve. He notes that the neuromers soon desappear and insists that the fore brain neuromers are homologous with those of other regions.

Waters decides that the fore-brain is composed of [three or] at least two well-marked neuromers. He says: "Of the existence of the first I am in doubt. The first nerve arises in the same manner, though at an earlier period than the other cranial nerves, thus indicating, however slightly, its segmental character. From the second no nerve springs, but it is directly opposite to the eye, and the optic diverticula spring from its dorsal crest in a manner entirely comparable to the other cranial nerves thus pointing to the conclusion that, though highly specialized in existing vertebrates, it was originally not so closely identified with the brain itself, but was homologous with the brain itself. From the third no nerve arises, but I think it probable that still lower forms in still earlier stages will show some nerve arising at this point."

(2.) "That the mid-brain consists of two neuromers from which I have every reason to believe the third and fourth nerves take origin, and hence deserve to be recognized as segmental structures."

(3.) "That the hind brain consists of six neuromeres. In regard to this region I think the observation of McClure and Miss Platt are sufficiently satisfactory except as regards the origin of the sixth nerve and the abducens neuromere. This nerve I have found to occupy its theoretical position when its neuromere exists; when fusion has taken place between the trigeminus and abducens neuromeres, the sixth nerve has been shifted backward toward the seventh and eighth nerves."

"It seems reasonably certain that the central nervous system of the primitive Vertebrate form consisted of a series of symmetrical segments, of which those of the neuron held the same relation to the mesoblastic head-segments as did those of the cord to the protovertebræ, i. e. were intersomitic; that those of the head, ten or eleven in number, gave origin to their respective nerves precisely as did those of the cord to the spinal nerves; that, in fact, the two regions were perfectly homologous in origin, character and function."

In this connection it will be remembered that Froriep has announced metamerism of a similar sort in the case the mole (two metamers in the diencephalon and three in the mesencephalon.)

In the recent paper by the same author reviewed elsewhere in this number Froriep withdraws from this position and says that while the position of these folds may be determined by the nerves the origin of the folds is a passive mechanical result of rapid longitudal growth in a limited space. He regards them as of no morphological significance. He concludes: "The jointing of the vertebrate body is originally determined by the middle germ layer; where ectodermal structures exhibit segmental arrangement it is a result of secondary adaptation to metamerism of the mesoderm."

In forming any estimate of the metameric significance of these diverticles as they undoubtedly appear in the fore-brain a few fundamental considerations must be kept in mind. (1) The morphological front of the brain cannot be beyond the infundibulum. The pituitary is historically closely associated with the neuroporus on the dorsal aspect. The olfactory is allied with the pituitary but is a dorsal organ (Amphioxus, Cyclostomata.)

(2.) It is scarcely legitimate to count dorsal diverticles like those of the fore-brain with ventral expansions like those of the mid-brain and hind-brain. Waters and others seem to have made this mistake.

(3.) The optic diverticle is not to be directly compared with the others but is more like a belated portion of the ganglionic ridge. The morphological entrance of the optic fibers is caudad of the hypophysis-olfactory region.

(4.) If the olfactory is the first dorsal root the ventral floor of its neuromer is in the mammillary region.

((5.) The hypoaria and their homologues may represent a second ventral expansion.

(6.) The formation of the mesencephalic flexure and saddle cleft may have played an important part in modifying the originally simple arrangement of the third and fourth nerve roots.

(7.) The isthmus has been greatly disturbed by the formation of the cerebellum and pons. The interpeduncular body represents a rudiment which may throw light on the apparent absence of nerves from this important segment.

The study of the black snake and garter snake embryos, while not completed, suggests the following statements:

(1.) The first embryonic vesicle suffers almost complete rotation about the hypophysis (infundibulum.)

(2.) The mouth of vertebrates is terminal or sub-terminal, the stomatodeum being morphologically the modified skin of a dorsal region of the head.

(3.) The chordal part of the brain represents its entire length, the so-called pre-chordal being but revolved dorsal projections.

(4.) Premature closing of the nerve tube due to cephalization has served to retain the homologues of certain ganglia in the medullary tube.

(5.) The formation of the primary optic vesicle is a belated separation of such a pair of ganglia.

(6.) The fibres of the special sense nerves may retain the habit of ordinary sensory fibres of producing bifurcating collaterals.

(7.) If neuromeres once existed in the fore-brain they would only be visible at an early stage and would be obscured by the altered conditions. The so-called fore-brain neuromeres differ from those of the medulla and cord in involving only dorsal structures. They are wholly illusory from a morphological point of view.

(8) The position of the optic recesses is morphologically secondary and must not be given a too prominent morphological rank.

(9) The commissures (præ-, callosal, fornix, habena, supra- and post-,) are similar and belong to the dorsal system. They are interrupted by the complicated system of dorsal diverticles.

(10) Two subdivisions occur in the base of the mesencephlon at an early stage but they do not correspond to the 3d and 4th nerve roots, both of which lie in the caudal member.

(11) The isthmus is longer than any of the so-called neuromeres.

(12) The trigeminal neuromere is well and early developed. The roots of the nerve pass both cephalad and caudad into adjoining neuromeres. It is possible to regard it as representing, with the third and sixth nerves, three primary neuromeres.

(13) The fourth hind-brain neuromere is no larger than the seventh and eighth.

(14) The fifth and sixth are nearly equal and give rise to the ninth and tenth in a similar way. The eleventh is seggregated at a late period.

(15) The cord is distinctly segmented at one period. This segmentation is of a sort inexplicable by appeal to mechanical effects of the metamerism of the protovertebrae.

(16) The neuromeres of the medulla cannot be ascribed to the mechanical effects of the anlags of the nerves, for those segments which have no nerves develop equally with the others.

(17) The auditory sac and ganglion and other structures of this region do not enhance but rather suppress the neuromeres.

It is hoped soon to present the evidence more fully than is now possible.

The youngest stages of Eutænia at out disposal are represented by a somewhat oblique series about parallel with the middle part of the medulla. The embryos are figured on Plate XVI, Figs. 1, 2. The sections, Plate XVIII, Figs. 5—9, plainly show that the medulla is distinctly segmental at this early stage and that the segments have a definite relation to the cranial nerves. There are five such expansions beginning with the trigeminal which is larger (though not so obviously as later) than the rest. In spite of the great flexures of the mesencephalon it is obviously composed of at least two parts.

Similar sections parallel to the axis of the mid-back region show that, at this stage, the neuromerism is confined to the medulla (See Fig. 12). In the oldest specimens seen the same relations prevail except that the cephalic parts are exagerated. Plate XVIII, Figs. 1—4, represented four sections nearly parallel with the medulla. The embryo from which these were taken is figured Plate XVI, Figs. 4—5.

In general, the medulla may be divided into three portions: The isthmus, or that narrowed portion which lies cephadad of the trigeminus; second, the expanded portion including the neuromeres of the fifth, seventh and eighth nerves; third, the remaining neuromeres which grade into the spinal portion. There is some evidence that the isthmus contains two neuromeres, the expanded portion contains three and the remainder two obvious expansions.

The neuromeres are well seen in Plate XVII, Figs. 1–6, and in the sections from black snake embryos. Plate XIX, Figs. 4–5.

The figures of Plate XVII show the extended roof of the diencephalon at this age, also the great development of the optic and infundibular recesses. There is a recess at the cite of the future mammillaria, as in fishes. There is a thickening in the region of the pes where rapid proliferation is going on. This is obviously preparing for the extensive anastomoses described in a previous paper.

The floor of the mesencephalon is obviously composed of two portions but evidence is wanting to show that there are distinct neuromeres corresponding to the third and fourth nerves.

The first neuromere (isthmus) of the medulla is about twice the length of the others and from its roof the cerebellum is developing. The trigiminal neuromere is greatly expanded but is not longer than others. The third expansion has no root at this stage. It is not unreasonable to suppose that the trigiminal has gathered up roots from the neuromeres cephalad and caudad. It would thus represent three neuromeres, while the sixth could be looked upon as a remnant weak and small.

The fourth expansion receives the eighth from the anlag on the auditory sac and gives rise to the seventh, while the fifth and sixth neuromeres are as usual. Fig. 4, of Plate XIX indicates that this neuromerism is even more prominent in the cord than in the medulla. It seems impossible that these remarkable and regular changes could be due to mechanical effects of the mesoderm segments.

THE ORIGIN OF THE TUBER OLFACTORII.—Plate XV, Figs. 9–11 gives quite a clear idea of the origin of the olfactory structures. As the epithelium begins to invaginate the proliferation increases, neuroblasts accumulate on the side nearest the brain and soon the olfactory nerve fibres extend mesad. The development of a moniliform series is very obvious. Instead of reaçhing the front of the cerebrum, as in other vertebrates, the lateral aspects are reached. Even before the nerves effects entrance into the walls of the cerebrum the latter become concave. In this way is formed the large olfactory fossa which is the most remarkable peculiarity of the rhinencephalon of Ophidia. The tuber as such is not developed but the olfactory structures occupy the ventro-lateral aspects of the frontal protrusion of the brain, while the mesal wall is simply thinned out. The developed of the glomerulary structures has not yet been followed in detail but it seems probable that a number of neuroblasts actually adhere to the cerebral surface and penetrate it.

If we are correct in believing that all nerve tracts and trunks are derived from moniliform adhesions it is not a matter of so vital importance what source the successive elements of a series may have had.

In this connection we call attention to the following points respecting the olfactory from another group.

The relations of the olfactory apparatus of mammals may be particularly well demonstrated in mouse embryos at the stage when the vibrissæ are in process of early development. The specific olfactory apparatus in the epithelium need not be described, but the fibres arising from the ganglion cells of the olfactory epithelium may be traced back as one continuous cord with an occasional sheath corpuscle attached until it enters the inter cranial space, here the fibre loses its sheath in the glomerulary mass This mass seems to contain, 1st, sheath-forming corpuscles; 2d, corpuscles of the same sort as those which occupy the vicinity of the ventricles. The fibre, after passing into the glomerulary zone, subdivides dichotomonsly and is lost among the "protoplasmic processes" of the specific olfactory cells. It is as yet uncertain whether the latter are developed from the tuber (pes) or are an integral part of the pero brought thither by the proliferating olfactory epithelium.

There is a cell-less interval separating the specific olfactory cells from the glomerulary zone in which the fine branches of the former can be readily seen. The axis-cylinder process passes into a stratum just peripherad of the dense layer of (nutritive?) corpuscles near the epithelium and enters the radix lateralis, which, at this stage, is well developed. There are still mitosis figures adjacent to the ventricle in the tuber as well as in certain parts of the olfactory epithelium.

The radix lateralis may be traced back to the ventro-lateral depression at the cephalic end of the pyriform lobe where a part of the fibres seem to dip directly into the substance and another part remains superficial and follows the depression named until the point of union with the lateral aspect of the thalamus is reached. A part of the fibres pass into the latter' body to lose themselves among its cells.

PLATE XV.

Fig. 1. [206–3]. Section through the head of the youngest Eutænia embryos passing through the lense capsule and primary optic vesicle. The figure shows the connection of the lense capsule with the rest of the cephalic sensory plate (*ceph. s. p.*)

Fig. 2. [211–5]. Similar section of the second stage of Eutænia (Plate XVI, Fig. 3.) The lense capsule has closed and the nasal sac is invaginating.

Fig. 3. A portion of the brain tube showing the relation of spongioblasts and neuroblasts. Dividing neuroblasts (*k*) along the ventricular surface give rise to neuroblasts (*n*) which make their way among the spongioblasts (*sp.*) to the surface, there to form the neurons.

Fig. 4. From *a*, Fig. 2. Numerous karyokinetic figures in the neublasts are visible and one or two instances of mitosis in the spongioblast nuclei (sp^1.) Well developed neurons are also scattered near the surface.

Fig. 5. From *c*, Fig. 2. The peripheral portion has already become reduced to a semi-gelatinous stroma in which the neurons in various stages are forming both axis cylinder and protoplasmic processes.

Fig. 6. A portion of the eye and lense anlag in an embryo of the same age as Fig. 1.

Fig. 7. A portion of the retina in Eutænia embryos of the same ages as Fig. 2, for comparison with the structure of the brain walls (Fig. 3.)

Fig. 8. Epithelium from the sensory plate near the nasal sac. (Fig. 2.)

Fig. 9. Epithelium over the area from which the olfactory pit is to form, in youngest embryos of Eutænia. [206–4].

The space between the epithelium and the cerebrum is occupied by the undifferentiated embryonic material.

Figs. 10–11. Portions of the olfactory epithelium in the middle stage of Eutænia showing the origin and migration of the ganglion cells whence the olfactory nerve arises and passes to the tuber. [210–12].

PLATE XVI.

This plate illustrates the external appearance of the four broods of snake embryos described,

Fig. 1. Entire germinal disc and embryo of the youngest Eutænia (E. I) moderately enlarged.

Fig. 2. Head of the same, enlarged.

Fig. 3. Embryo of the same species, two days later.

Figs 4–5. Embryo of the same species four days later than Fig. 3[*].

Figs. 6–7. Black snake embryo taken July 19th.

PLATE XVII.

A series of perpendicular longitudinal sections through a Eutænia embryo of the age figured in Plate XVI, Fig. 3. The sections are taken in such a way that, on account of the lateral curvature of the specimens, (compare Fig. 5, Plate XVI) the medulla is obliquely cut. The position of the median line is indicated by a star (*) in the several sections. [209–7, 6, 5].

In Fig. 1, the eye and ear vesicles are cut. Especial attention is called to the connection of the pituitary and nasal sac via a continuous columnar epithelium.

Ftg 3, especially illustrates the development of the trigeminal system.

Figs. 4 and 5 show the neuromeres of the medulla distinctly,—while Fig. 6, which is nearly mesal in front, has the theoretical axis of the

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[*] It should be added that the young are not born until the latter part of July. July 22, 1892, the young were fairly well developed and had two rows of dark spots on the dorson and splotches on the sides instead of the stripes. The snakes were capable of motion though about one-quarter of the yolk remained. The shell is transparent, not white like that of the black snake. It seems legitimate to infer that the progenitors of Eutænia were spotted like the Tropidonotus group.

brain indicated by a dotted line as well as the boundaries of the several compartments.

PLATE XVIII.

Figs, 1–4. Four sections from a nearly horizontal series of the oldest embryo of Eutænia (Plate XVI, Figs. 4, 5.) The mesencephalon is obliquely cut and in Fig. 4 the roots of the oculo-motor (III) are in section. The medulla neuromeres are numbered beyond the isthmus as follows: V, VI. VII, IX, X, in accordance with the chief nerve. The isthmus has no nerve, its roof being formed by the cerebellum. *Max* + *Mand.* The maxillary and mandiblar parts of the trunk of the trigeminus, the opthalmic being obviously distinct from the first. [208.]

Figs. 5–9. Five sections of the youngest Eutænia embroys [206]. Parts numbered as before. The neuromerism is quite as prominent as above.

Fig. 12. [207.] A section along the mid-dorsal region, showing that although mesomerism is complete there is no neuromerism, *i. e.*, although the muscular segments are well-formed, the neural tube is not segmented.

Figs. 10, 11. Two sections from the black-snake embryo; chosen to illustrate the substantial identity of neuromeric differentiation the two groups. [263.]

PLATE XIX.

Fig. 1. [207–5.] A somewhat oblique frontal section through the head of embryo of Eutænia figured, Plate XVI, Figs. 1, 2. [E. I.] The section is so taken that the caudal part of the mesencephalon is cut, and a portion of the primary optic vesicle (*Opt.*) The existence of a distinct sensory plate passing from the hypophysis about the protuberance of the fore brain and including the lense capsule anlag is illustrated; the latter point being shown in Fig. 1, Plate XV.

Fig. 2. [205–3.] Portion of the walls of the diencephalon of the black-snake embryo figured in Plate XVI, Figs. 6, 7. The point from which the drawing is taken is *Fig. 8a*, of the present plate. This figure illustrates the elongation of the spongioblast (*sp*), the dividing neuroblasts with karyokinetic figures (*k*), the granule cells (*gr.*) which are regarded as indifferent nervous cells out of which neurons may be subsequently formed, the neuroblasts transforming into neurons (*nb.*) and giving off axis cylinders (*a. c.*), in this case, caudad,

Fig. 3. Drawing of a part of the cerebral wall from an embry dog. The portion selected is from the frontal region and illustrates a similar process in a later stage.

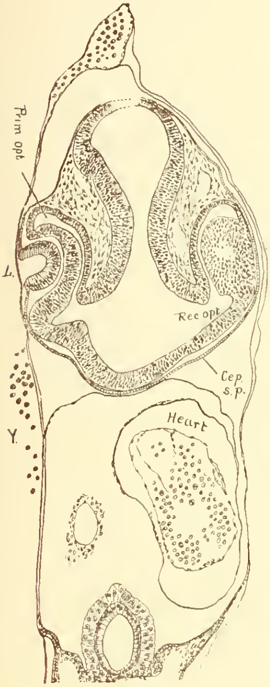
Figs. 1 and 5. [204–7, 8.] Nearly perpendicular longitudinal sections through the head of embryonic black-snake (Plate XVI, Figs. 6, 7.) Both sections are near the lateral surface, Fig. 5 being the deeper. The neuromerism of the medulla is well shown.

Figs. 6 and 7. [202–7.] These figures are from the four or five day chick embryo for comparison with those of Plate XVII. Tne chick is obviously in a somewhat later stage. The flexures are apparently less, but this is due to a backward revolution of the cerebral end.

Figs. 8. [205–3.] Horizontal section of the fore-head of a black-snake embryo (Figs, 6, 7, Plaie XVI.) The formation of the lateral vesicles and the distinctly double character of the diencephalon are noteworthy.

Fig. 9. [208–9.] Section similar to Fig. 1, from oldest Eutænia embryo. The section is immediately in front of the hypophysis and shows the upper jaw rudiments.

Fig. 10. Section through the auditory capsules of the Eutænia embryo figured Plate *XVI*, Fig. 3. The hyoid centrum is forming at *H. Au.* auditory vesicle.



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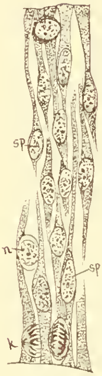

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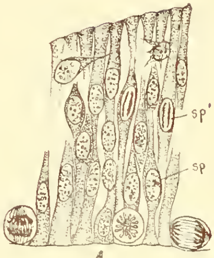

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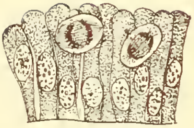

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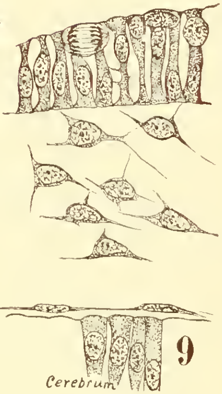

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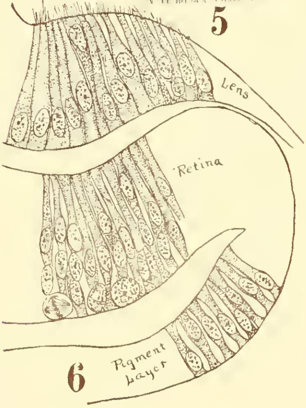

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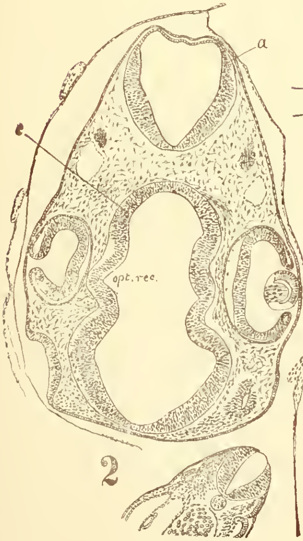

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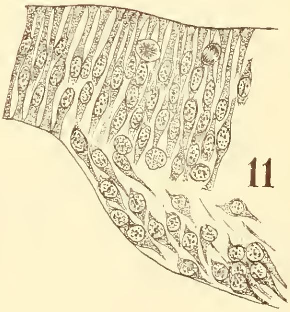

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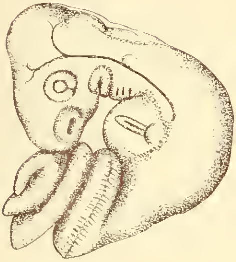

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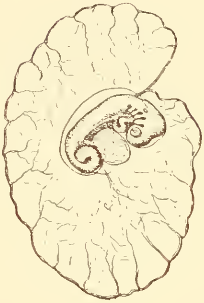

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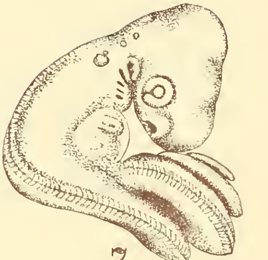

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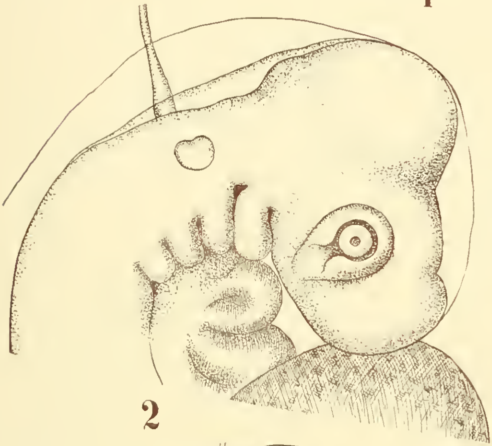

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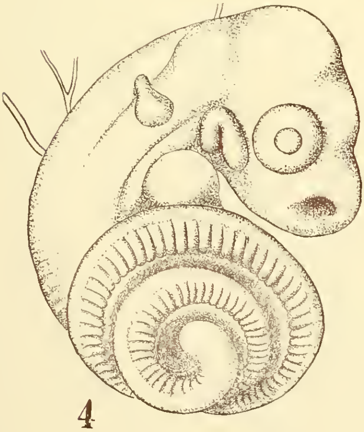

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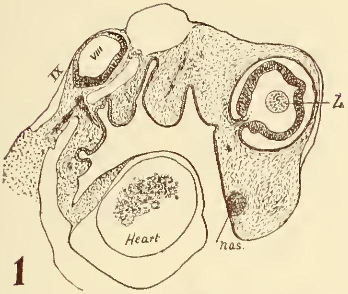
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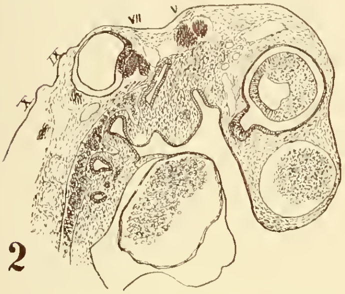
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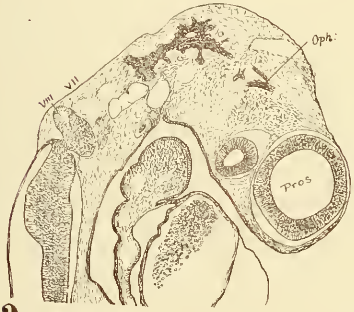
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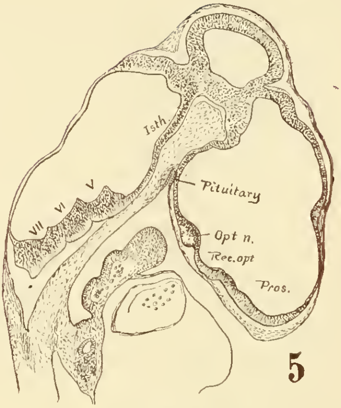
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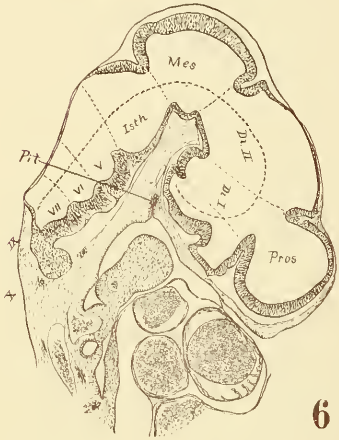
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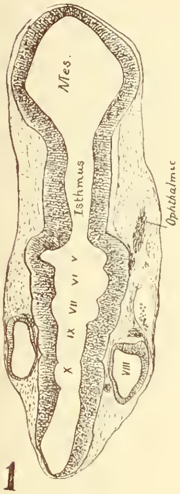

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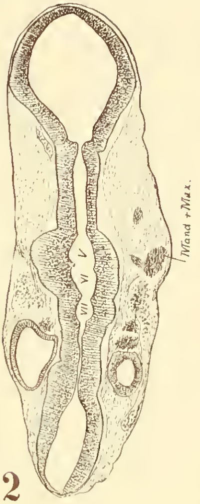

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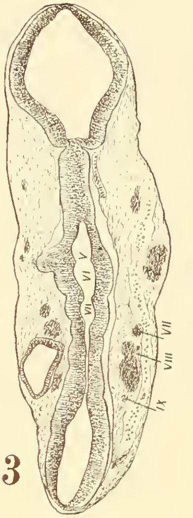

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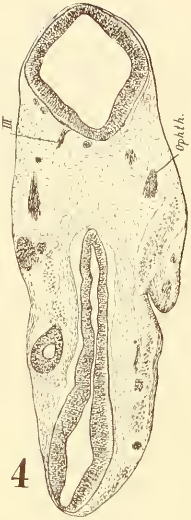

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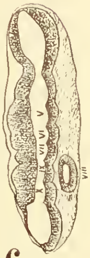

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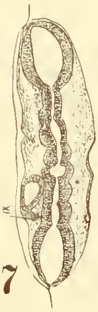

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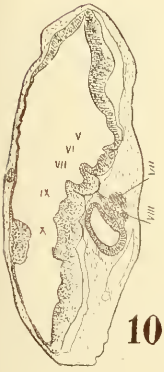

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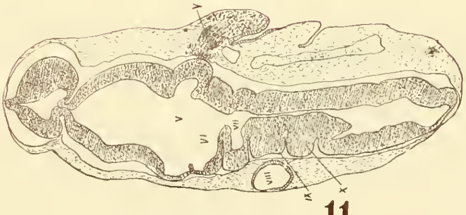

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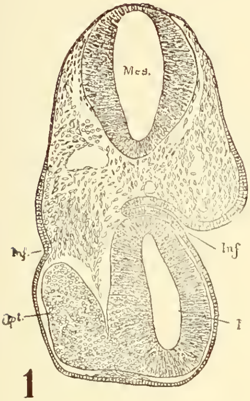
Journal of Comparative Neurology, Vol. II. PLATE XIX.



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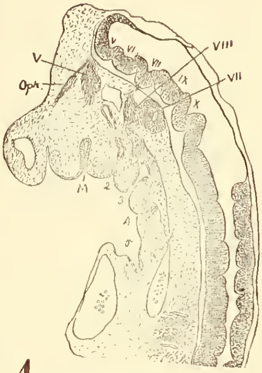

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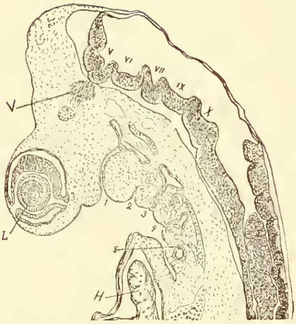

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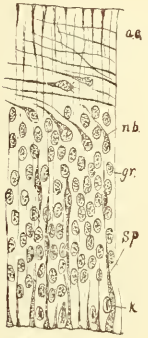

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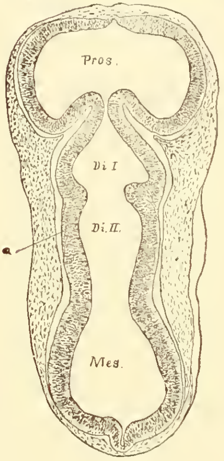

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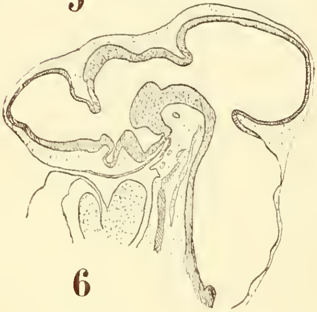

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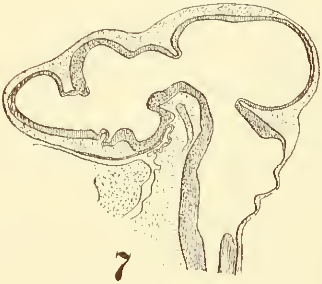

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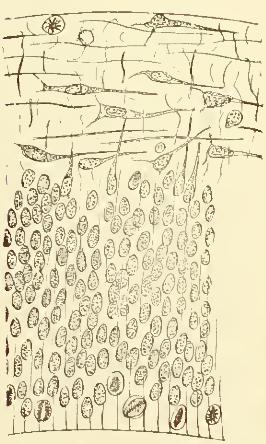

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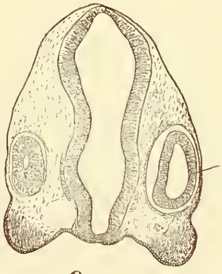

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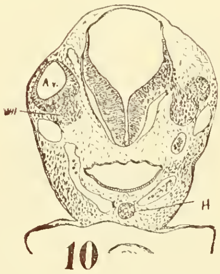

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THE NEURASTHENIC FACTOR IN THE DEVELOPMENT OF MENTAL DISEASE.

A. B. Richardson, M. D., Superintendent of the Columbus Asylum for Insane.

To have an intelligent conception of the relation of nerve exhaustion to the development of mental disorders it is necessary to learn something of the manner in which the brain cells receive their nutritive supply and how the products of their physiological activity are removed. We will assume that the cells of the cerebral cortex are the chief organs concerned in the evolution of mental phenomena, and that a study of the physical basis of mind is a study of these microscopic bodies, their connections, supports, sources and methods of renewal and the manner of their riddance of waste and deleterious products. After these have been as fully investigated as the facts at hand will permit, we will then be in position to investigate in what manner they are disordered in the various stages of the development of mental disease, and I have chosen the name which heads this paper because I believe it wise to impress the fact that these incipient changes are in every instance such as cause errors in the nutrition of the cell elements and derange the normal balance between their supply of assimilative material, on the one hand, and the demands made upon their stores of energy, on the other.

The histology of the cells of the cerebral cortex has been carefully studied of recent years. Many useful facts have been established, but much remains more or less uncertain. We shall not attempt a review of this further than to describe their relations to the other constituents of the cortex.

The brain cells of the cortex lie imbedded in a soft matrix of delicate branching cells, composed of numerous branching fibrils from a small central focus, which entwine in all directions and form a most delicate cushion for the support of the more highly developed brain cells. Their uses seem to be those of support of these cells and possibly a share in their nutrition.

The brain cells, proper, are connected with the exterior and with each other, by both direct and indirect methods. They have two or more branching fibres or poles, through which their connections are effected. Some of the cells have a basal process which does not diminish in size and has in some instances been connected directly with an axis cylinder of an efferent nerve filament. The other processes diminish gradually in size by subdivision until it is very difficult to trace them to their termination. They seem finally to form a delicate matrix of fibrils, and many of the cells have no distinctive processes other than those which form this matrix. From the aggregation of the fibrils of this matrix on its ventral side larger fibres arise which have been traced into the axis cylinder of other nerve fibres. Whether or not this difference in the connection of the brain cells with the axis cylinders of the nerve fibres indicates a different function in the two classes, is not well determined, but analogy would indicate that it does so, and it has been assumed that the direct connection is with efferent nerve fibres and the indirect with afferent fibres.

The blood vessels to the central cortex are exceedingly delicate in structure and are susceptible of great variation in diameter. In the capillaries the various coats disappear, leaving the endothelial lining alone, and this is quite delicate in structure.

The blood vessels lie in a lymph space, which is much larger than the diameter of the vessel and is probably lined with a delicate membrane which closely invests the brain tissue. About the brain cells there is a similar lymph space and these peri-vascular and peri-cellular lymph spaces have been seen to be connected by lymph tracts or clefts in the brain substance, which thus afford a direct drainage of the cell surfaces into the great lymph reservoirs between the membranes of the brain. Along the course of the vessels and in the neighborhood of the cells, most delicate and almost indiscoverable (in the normal state) cells are found which are sometimes connected to the vessel and reach out toward the cell elements. In pathological states these become much more visible, increase in size, are more readily stained, and become filled with the products of cell degeneration.

These anatomical data will enable us better to understand the pathological changes which are found in incipient mental disorders and to note the connection which they have with the problem of nutrition. Still beyond our vision lies the field in which the connection is made between mind activities and the brain elements, and the seeming impossibility of the solution of this problem has necessitated the introduction of theory in the treatment of the subject of mind disorder; but theory is often admissable as a basis for guidance in therapeusis or prophylaxis and for such purposes we shall not hesitate to use it when full investigation partly fails.

The primary steps in the development of mind disorders would seem to be dependent upon the following anatomical, physiological and pathological data: (1). The capacity of the cell elements of the cerebral cortex to assimilate nutritive material varies in different types of cells as found in different organisms, and in some is defective. (2). That susceptibility of these cells to impressions, which gives them their functional power, is possessed by different types in varying degree and in some is excessive and out of proportion to the assimilative capacity of the same cells, in others is deficient. (3). That delicate poise of functional power in the brain cell, which, on the one hand, enables it to react to impressions, and on the other gives it the power to restrain, inhibit and direct the results of these impressions, is possessed by different types of cells in varying degree. When deficient in delicacy it results in defective capacity and the nutritional errors which are due to inactivity. When the normal power of reaction is present but the power to inhibit and direct is deficient, excessive reaction, and particularly such as is disproportionate to the supply of nutritive material assimilated by the cells, leads to serious cell degeneration.

It is only by some such terms as these that we can intelligently explain in physiological language the transmitted, congenital or acquired tendency toward mental derangement. The want of balance in the brain cell between its capacity and opportunity to assimilate nutritive supplies, on the one hand, and its susceptibility to impressions and its power to exercise inhibitory control of its energy, on the other, is handed down from defective parentage, is the accompaniment of arrested development, or is the penalty left by previous disease.

As the result of the first of these causes, to-wit, the capacity of the cell to assimilate nourishment, some types of cells have a very limited functional capacity, within the limits of safety, and slight power of resistance. They are easily overworked and their possessors constitute oftentimes the mental invalids which abound to enliven the tedium of the busy practitioner. Still other types of cells are essentially short-lived, coming early to maturity, possessing their maximum of functional power for a comparatively short period, and soon falling into decay and the degeneracy of premature old age Hysteria is an excellent example of a form of mental disorder due to the third class of cell defects, and has its origin in defective inhibitory control of cell energy. That recovery from mental disease is so seldom satisfactory, and the tendency toward recurrence after one attack is so great, is due to the changed nutrition of the brain cells and their diminished capacity to assimilate nourishment. It is to be borne in mind also that the large lymph spaces around the blood vessels of the brain and about the brain cells, and the connection seen between these in some cases, at least, indicate the importance which we must attach to the rapid elimination of waste products from contact with the cellular elements. The products of cell metabolism are extremely inimical to the normal activity of the cells, and their toxic effects upon the system have been fully established.

To understand more clearly cell nutrition and cell energy and their delicate adjustment and interdependence, we must remember that there is an extreme susceptibility in these carrying blood vessels, to stimulation from the activity of the cells themselves, and that their calibre and the supply of material which they convey, vary with the slightest variation of cell activity, or their stimulation from the exterior. With this varying calibre and the consequent changes in the blood pressure come the modifications in the relation which the nutritive supply bears to the activity of the cell. There is a genuine hyperaemia of the brain cortex during its period of activity, which seems essential to the rapid evolution of energy, and during which both the amount of nourishment consumed and of waste products produced are increased. During the periods of quiescence in cell activity, the blood pressure is diminished, the amount of nourishment sent to cells is lessened and the waste products diminished, yet it is then that the cells store up energy because their activity is almost nil and the balance is far on the credit side of the account.

Reasoning from these data, then, we see that the incipient variations in cell nutrition and consequent mental derangement, come from two sources, the first those that diminish the amount of material assimilated by the cell, the second, those that increase the demands made upon it. The first of these may be induced indirectly by a diminution in the amount of the blood or a deterioration in its quality. In such states there is an anaemia of the brain cell, in some cases, and, in others, a passive hyperaemia, the result of a want of proper tonic in the vessels. Much oftener, however, the diminution in the nutritive supply depends upon a genuine hyperaemia of the cortex. The increased pressure of this, which is either excessive in degree or continued beyond the normal limit, prevents the healthy transfer of nutritive material through the vessel walls. The cause of this abnormal hyperaemia is usually the over stimulation of the cells themselves. This of itself endangers the safety of the cells by increasing their requirements for nourishment. It is impossible to separate the effects of these two causes. Overstimulation of the cells accompanies the thousands of exciting causes of mental disorder. None, however, is more effective in its production than worry. Whatever may be its origin this induces a rapid destruction of tissue in the cerebral cortex. There is a prolongation of the normal hyperaemia, and an inability of the vessels to contract upon their contents with the normal diminution in their stimulation, due to exhaustion and paresis of their nervous control. It is not difficult for any one to test this in himself. Apply yourself to intellectual work which is felt to be a strain on you and continue this to an hour beyond that usual for your retirement. You will notice how difficult you will find it to settle your brain for repose, and how long before refreshing slumber comes to your relief. Worry acts in a similar manner and we have all felt its disquieting influence, lying awake hour after hour in a vain attempt to calm the restless activity of our thoughts. There is an irritability of the nervous tissue which is the product of exhaustion and an evidence of its defective nutrition, or what is equivalent, of its overstimulation. This irritability simply means weakened inhibition, which is as surely a sign of exhaustion as is the want of the power to react to an impression. Repetition of this prolonged hyperaemia leads to it's easier production. The nutrition of the cells soon becomes permanently modified. They energize differently. The vessel walls become permanently distended. They are not equally strong at all points and aneurismal dilations or pouches form along their course. Obstruction results to the blood current. Nutrition is more greatly impaired. The contents of the vessels transude through their walls under the increased pressure and block up the peri-vascular lymph spaces. The changes in the vessel walls also favor this. The flow of the waste products is obstructed and the cells become bathed in the products of their own metabolism. The toxic effect of these still further deranges their functional activity. Permanent degeneration of the cells soon ensues. They change in form, their prolongations become rounded off, their interior becomes granular, or is filled with fat globules. The delicate plexus from which springs the afferent nerve fibrils is permanently damaged. The scavenger cells become enlarged, more visible and filled with the products of cell degeneration. Finally the entire cell is removed or so disorganized that its distinctive features entirely disappears. These changes are seen in exaggerated degree in such forms of mental disorders as paretic dementia, in which the nutritive changes and consequent loss of power are rapid and marked.

Bear in mind that in all these cases the incipient change, the first step in the degenerative process, is a simple error in cell nutritive,an interference with the opportunity to secure sufficient nourishment and a demand for more energy than the supply given will produce. When the problem is in its simplest form its solution should be comparatively easy, let it become complex through the lapse of time and its solution is no longer possible. when the vessel walls become changed in character or even dilated permanently, the recuperation is slow and does not always advance with the improvement in the general condition of the patient. The nutritive error in the cell elements of the brain often continues long after the general condition has improved. I know of no other form of disease in which such patient perseverance in well doing is necessary.

The treatment of such nutritional errors is a complex subject. It will require every resource of the physician and tax his ingenuity to the utmost. It is by no means restricted to the use of medicinal agents. The first requisite is a sufficient supply of assimilative material of good quality as represented in healthy blood. The second is to secure the opportunity of the brain cells to receive this by a correction of the hyperaemia, obstruction or degeneration which has prevented it reaching them. The third is to diminish the demands upon the cells so that their work shall not be in excess of their recuperative power. The fourth is to secure the prompt removal of their waste products by clearing the channel of the lymph spaces of the debris which has come from the obstruction of the blood current. The fifth is to divert the functional activity of the cells from the directions in which it is defective, and to develop new functional tendencies, new habits of action, if such they may be called, to the end that the healthy balance may be re-established. We are required to repair their diminished inhibitory control and to stimulate them to activity where disuse has led to disorder.

We have not space to go further into details, but it may be said, in general terms, that medicinal agents are not so potent as the regulation of functional activity in the cell elements.

NERVE HYGIENE.[1]

BY DR. AUGUSTUS FOREL.

Professor of Psychiatry in Zurich.

"Too many nerves and too little nerve," complains Professor von Krafft Ebing of our generation. What do they mean, "nerves," "nervous," "nervous prostration," *neurasthenia*, and similar terms?

We must first clear away a common mistake, as if all this had reference to the nerves of the skin or of various parts of the body. It is no more these that are "nervous" than the fingers of an amputated arm which cause the pain that the former possessor of the arm imagines he feels there. Arm and fingers dissappeared long ago, were buried after amputation and are now decayed, and yet there is a sensation of pain as if they were still present, the seat of the disease.

It is nothing but the brain that is "nervous." We make the mistake of attributing its excitement to the so-called sensory nerves of the body, because usually they convey to the brain the impressions of the external world, such as light, warmth, sensation of touch, sound and odors. It is the brain alone that occasions the sprawl, the convulsive twichings of the nervous woman, the deceptive senses of the victim of delirium tremens, the evil conduct of a drunken man, the great deeds of the genius, the indolence of the man who hangs around the saloon, the folly and the pain of insanity, the misdeeds of the criminal and the industry of the sober laborer.

In health, in the sound working capacity of the brain, lies the chief condition for happiness. Professor Hiltz is certainly right who believes that the happiness of an individual depends

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[1] No apology is necessary for reproducing, in connection with the thoughtful article by Dr. Richardson, whose eminence as an alienist will command attention for what he writes, the above selection from the pen of one of the greatest psychiatrists of Europe. The subject, which is awakening remarkable interest on the continent, has hardly yet attracted merited attention here. Our obligations are to Mary G. Stuckenberg, whose translation (with slight modification) we borrow.

upon his fulfilling the purpose of his life by labor. But since man's labor is not accomplished like that of the plant and the lowest worm, for he applies a higher understanding and feeling to it, the fundamental possibility of happiness for him lies in a sound brain.

How are you going to convert a sound brain into a happy spirit, disposition and will, and keep them up? By continually patching at an impaired organ with medicines and cures in nerve or lunatic asylums? Such patchwork is good, or perhaps a necessity, if injury has already taken place, or has become great. But always the best prescription is prevention, in general, that one which any reasonable person can apply without either physician or apothecary.

Would you, by means of poisonous stimulants, urge the incapable modern brain to some unusual activity, which necessarily must exhaust and incapacitate still more? That would be putting out a fire with petroleum. Yet it is just what we are doing when we use alcoholic drinks, morphine and similar so-called nerve tonics. We injure the organ we desire to strengthen and wear it out prematurely. We see the fruits of alcohol-drinking in the saloon and in large part in the nervousness of our age. We see them in the prisons, the lunatic asylums, the idiots, the vagabonds, the idlers—consequences that are only partly the result of the drinking customs of these people themselves, those of their forefathers bear part of the blame.

Of course the use of alcohol is not the only occasion of the "nervousness" of our age. There are others, such as poverty, over-population of the cities, insufficient nourishment, but especially the unsuitable, the thoughtless marriages of stupid, eccentric or evil people, whose defective brain peculiarities perpetuate themselves in their posterity and contaminate society with incapable, lazy, untruthful, immorally inclined, in brief, with individuals that are a menace to the general good.

How ought and can we oppose these evils, successfully overcome our nervousness, and grow happier? That riches cannot make us either healthy or happy, that poverty occasions unhappiness and disease, has been so clearly shown that we need lose no words upon this subject. It stands approved by experience that nerves and muscles which remain inactive lose strength and shrink; and just so the brain needs exercise, and in fact, earnest, hard labor, but not too one-sided, in order to become and remain strong and healthy. Over-weariness and over-exertion, however, injure the brain as they injure muscles and nerves. To furnish power and working capacity, the muscles and nerves require a sufficient amount of such nourishment as will produce matter and force; but over-feeding is an injury. It is just so with the brain.

Sleep is the indispensable rest of the brain during which it recovers the substance lost by the wear of the day and gathers up strength. Good sleep is the fundamental requirement for brain health. Every nerve stimulant, and on the other hand all substances that produce artificial sleep, are nerve poisons and are to be condemned by a healthy nerve hygiene. The worst foes of the human brain are alcohol, morphia, ether, cocaine, and the like. Their use is never justified except very temporarily as medicine, or in order to allay the pain and the agony of death in a fatal illness.

Every one who desires to secure and to strengthen a healthy and useful brain, must really labor, and that daily, and not too little. Four hours of work a day for a healthy being is altogether too little. Let any one spend his time in enjoyment and idleness, and enjoyment soon ceases to be enjoyment. He will accumulate artificial wants in ever increasing numbers until they burden his life. He will become more and more dependent and morose. His mental horizon will grow narrower continually and more rigid. The plastic brain of youth, that is, its docility and adaptability, will become less and less active and capable of comprehending and elaborating new thoughts.

On the other hand, mental labor preserves the plasticity of the brain to a much more advanced age. Idlers, therefore, in spite of the best brain capacity, become prematurely old mentally, narrow-hearted, limited in horizon, and not seldom absolutely stupid. We often observe moderately gifted students becoming, by means of work, men of power, and highly gifted young men, as a result of idleness, gradually grow useless, peevish, and now and then narrow-minded Philistines.

Secondly, one must not overwork. The work day must not be prolonged into the night. One ought not to continue to labor with an exhausted, harrassed mind.

Thirdly, it is necessary to take sufficient nourishment, but one must not overeat—must partake of farinaceous food, the fats and albumen in proper proportions

Fourthly, eight hours of sleep are a necessity, and above all one must not retire too late. There must be no excesses of any kind.

Fifthly, all alcoholic drinks as well as all artificial producers of sleep and nerve stimulants must be absolutely avoided, as a matter of principle. Resolutely and bravely turn the back upon all places of tippling and seek the society of total abstainers, for to them belongs the future. Those people who wholly abstain from alcohol and the other things mentioned are more capable of work, healthier, happier and live longer. They do not endanger their posterity, run no risk of picking up some venereal disease in a state of intoxication. * * * Poverty and social enslavement are also the daughters of alcohol and the mothers of nervousness and of brain stupefaction.

But nervous people and those who have weak nerves ought especially to regulate their lives according to these principles. Often they are cured by this means alone, without a physician, without drugs. Of course, however, since in their case the brain is already enfeebled, they are in need of a different prescription; they will be obliged to engage very moderately in mental labor, in fact, not at all until there is improvement, meanwhile exercising the muscles in order indirectly to provide the brain with power substance. The best means of all is ordinary labor on a farm, on generous, nourishing diet, and water. This method of cure I have prescribed for distinguished patients, ladies as well as gentlemen, which met with the very best success.

But thus far we have as yet done nothing to invigorate and improve the brain of our posterity. To take thought for that is certainly beautiful and important, although most people are too crass, egotistic or thoughtless to take practical interest. But in many cases only ignorance is the cause of criminal neglect of the subject. It is to the latter we address ourselves.

It is criminal towards posterity to bring forth children thoughtlessly or without taking counsel with conscience. The tendency to crime is transmitted, stupidity is transmitted, mental aberration is transmitted, malice is transmitted, indolence is transmitted, selfishness is transmitted; but, on the other hand goodness is hereditary, industry is hereditary, mental and physical health are hereditary. conscience and disposition are hereditary, intelligence is hereditary. Training and the experiences of life may more or less develop or arrest the hereditary disposition, but they can never produce or destroy them. Alcohol destroys the gifts of nature in the embryo of the brain, injures all of them and never can improve one iota.

When the love of a man and a woman for each other awakes a desire to become united for life, they ought never to forget that they are undertaking a very grave responsibility, the responsibility for their future children. They ought to renounce marriage rather than to produce physical, or what is much worse, mental cripples. Unfortunately, however, we see noble people with highly gifted natures who carry their prudence to so anxious an extreme as not to marry, or at least not to bring forth offspring, while the most frivolous, brutal and stupid, under the protection of lax laws that had their origin in a mistaken humanity, multiply like rabbits and carelessly abandon their progeny to the state or to public philanthropy—progeny made more liable to danger by reason of previous alcoholic excesses.

And with such false political economy, such mistaken breeding, is it any wonder this increase in the number of mentally diseased, of lunatic asylums, of a weak eyed proletariat, of morally defective vagabonds and criminals? There is talk of overwork as the occasion of these evils, overlooking the fact that this proletariat mentally never has overworked, but rather has been indolent and useless always. "Nervousness," really brought about by means of mental overwork, forms only a small and comparatively safe fraction, while the great, innumerable company of mental wrecks nearly always owe their catastrophe to diseased or defective brain conditions, to excesses, and in enormous percentage, to alcohol.

It is therefore a duty to consider hereditary conditions. Every respectable woman ought to look for solidity, soberness, good sense and a good disposition, as she chooses a bridegroom. The capable young man ought to have a care not to marry a money-bag, or a hysterical siren, or a body without a soul, but a sensible, modest, industrious, respectable and intelligent young woman.

Meanwhile, let the able-bodied and sound of brain not be affected by any silly, pessimistic philosophy, but seek each other in love and in marriage, bring forth children without careful regard of money, for, with the right choice in marriage, good fortune will not fail them.

But what shall we do with the others, with the eccentric, stupid, wicked, defective? This is a question as difficult as it is critical. They should be prevented from multiplying themselves, for they will only bring forth mental cripples, unhappiness for themselves and for their children. They bring forth unfortunates who will afterwards execrate their parents. One simple and safe counsel that ought, however, to reach the good as well as the evil, the highest genius as well as the dullard, would prevent much evil. Renounce forever all those systematically stupefying, brutalizing and demoralizing factors of human misery—the alcoholic drinks, and also the so-called "enjoyment" of narcotics. Flee the perilous counsel of the pessimists, who cry: "After us the deluge." That flood of mental disaster which these very people, so heartless and selfish, inflict upon their descendants may overtake themselve before death reaches them; for selfishness brings forth misery; love, happiness.

LOCALIZATION IN THE CAT.

By C. L. Herrick.

An operation, performed in connection with Mr. E. G. Stanley, which it is hoped to describe in full in a subsequent issue, perhaps deserves notice on account of its suggestiveness upon points raised in Munk's last paper in the Proceedings of the Berlin Academy.[1]

Munk states that in the dog and monkey the region for the extremities is concerned with the formation of tactile and pressure sensations and perceptions of the limbs of the opposite side. The tactile reflex is also located in this region and is completely lost when it is extirpated. In addition to this, this region is at least chiefly responsible for the pain sensations of the members; pain is dependent for its perception up to a certain degree of intensity on this region, and complete extirpation of the region nearly destroys the sense of pain which may gradually be gained by substitution of other regions. Again, there is a connection between the cortical centre and the reflex centre for the limbs, and that which inhibits the reflexes.

After removal of these areas the animal moves awkwardly, lifting the feet too high or too little, placing them irregularly so that the feet double under. There is a tendency for the feet to slip laterally from the body permitting the body to fall toward the side opposite the operation. These irregularities disappear, so far as superficial observation goes, completely.

The feet corresponding to the operation lose their responsiveness to slight tactile irritation. When a strong pressure is brought to bear there is reflex response, *i. e.* movement of the limb, but no evidence of sensation, as is proven by the fact that the head is not turned toward the irritated member as it is toward any other.

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[1] Ueber die Fuehlsphæren der Grosshirnrinde. Mittheilungen aus den Sitzungsb. d. Koenigl. Preus. Akad. der Wissenschaften zu Berlin. July, 1892.

Bechterew's mistake, according to Munk, is in not removing the entire region, enough of the cortex remaining to explain the evidence of sensation brought forward by the former.

Munk distinguishes between tactile reflex and general reflex. The former is completely lost, the latter reduced, but subsequently regained. He seeks to explain a part of the phenomena supposed by Goltz to be due to the repressive effect of irritative processes as the result of isolation.

Our subject was a half-grown kitten, and portions were removed from the left hemisphere in three successive operations, so that a long, narrow area extending from the crucial sulcus to the limits of the middle external gyrus caudad, and including nearly the whole of that gyrus, was extirpated. The entire thickness of the cortex and most of the white matter was removed. The first operation was apparently near the front of Munk's visual sphere and the kitten showed some disturbance of vision in the opposite eye, but, though the incision was subsequently carried further caudad, these symptoms did not reappear. After the last operation, which invaded the fore-leg area of Munk, there was decided disturbance of the motor and sensory functions for both limbs. The skin sensation and reaction against pain was reduced immediately after the operation, but these disturbances soon disappeared. The voluntary motion was but little disturbed but the fore foot tended constantly to double under and trip up and slipped helplessly away from the line of support. The hind leg was similarly affected, sliding laterad and failing to support the body. In walking and running no imperfection was noticeable, except when obstacles or changes in the direction of motion called out what has been described. Most noticeable of all was the change in the position of the limb when permitted to hang free. If the body were supported upon the ventral aspect the left legs were drawn up and quickly responded to any tendency to fall in that direction, while the right legs hung pendant and failed to react against a push threatening a fall to the right. The kitten was watched four or five weeks, during which time nearly all symptoms disappeared except those last mentioned, which remained to a certain extent to the last. Another curious effect of the operation was a strong tendency, for some time after the extirpation, to shake the feet of the right side (rarely the left hind foot in sympathy), as if they were wet or otherwise irritated. The shaking was apparently a reflex and was at times almost convulsively violent. It is to be compared with the scratching reflex described by Goltz.

In contradistinction to Munk, therefore, we find loss of muscular sense a more important and permanent feature than tactile or pressure disturbance, though the extirpated area extended further caudad than in his experiments. It must be observed that the area we removed lies farther from the median line than that operated on by Munk and affected directly only his fore limb area, though the depth of the excised portion suggests the possibility of an injury of other tracts.

We are confident, moreover, that many of the contradictory results of experiment are due to proliferating regenerations which supply the lost material in the case of young animals.

A SIMPLE ALCOHOL FORMULA.

Students frequently experience difficulty in recalling the proportions in which water should be added to alcohol of various grades to prepare the stock solutions for hardening gradatim. The formula given in our guides are singularly and absurdly complicated. The following may be suggested: Take as many parts of the alcohol given as the percentage required; add as many parts of water as the difference between the given and the required percentages.

Example. Given 70 per cent. alcohol to make 40 per cent. Take 40 parts alcohol of 70 per cent. and (70—40) 30 parts water.

LITERARY NOTICES.

THE BRAIN OF LAURA BRIDGEMAN.

The opportunity to submit the brain of a blind, deaf mute to scientific examination is so rare that it must be esteemed a piece of exceptional good fortune that in the case of Laura Bridgeman, whose mental powers have been so carefully recorded, a detailed examination of the brain has been attempted. While it is greatly to be regretted that the preservation was inadequate yet the data are of great value. The paper will be accessible to most of our readers [1] so that we will content ourselves with quoting the author's summary:

"From these fragmentary observations, which leave so many points connected with this special case still undecided, it will be advantageous to construct some sort of general picture.

"The anatomical condition was that of a normal brain in which the olfactory bulbs and nerves, the optic nerves, the auditory nerves, and possibly the glossopharyngeal, had all been more or less destroyed at their peripheral ends. This destruction caused a degeneration—most marked in the optic nerves—which extended towards the centres and involved them indirectly. This condition has left its mark more or less plainly on the whole brain, as indicated by the extent and thickness of the cerebral cortex, and specially by the cortex connected with these deficient sensory nerves. The physiological effect of the peripheral lesions, as I conceive it, was to retard growth in the centres, cortical and subcortical, which were thus involved, and also to interfere with, if not entirely prevent, the formation of the association tracts.

"To be sure, this case represents a maximum loss in these defective senses with a minimum amount of central disturbance, thus offering the very

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[1] DONALDSON, H. H. On the Brain of Laura Bridgeman.—American Journal of Psychology, Vol. III-IV.

best sort of opportunity for education by way of the surviving senses. At the same time, we must imagine the hemispheres to have been traversed in every direction by partly or completely closed pathways. The brain was simpler than that of a normal person, and Laura was shut off from these cross-references between her several senses, which usually so facilitate the acquisition of information and the process of thought. Mental association was for her limited to various phases of the dermal sensations and the minor and imperfect senses of taste and smell. Yet from their fundamental and protean character, the dermal senses are perhaps the only ones on which alone the intellect could have lived. We are thus brought back to Sanford's conclusion as derived from the study of her writings. 'She was eccentric, not defective. She lacked certain data of thought, but not, in a very marked way, the power to use what data she had.'

"One word more upon the cortex. The deficiency in the motor speech centre is mainly macroscopic, as far as the third frontal gyrus is concerned. The motor centre there had lost some, but not all its associative connections. Histologically, it was slightly deficient. The lesion there was so different from that of the sensory centres that a histological difference ought not, perhaps, to be surprising. The cortex of the sensory centres was not sunken below the surrounding level, though the gyri were slender and flattened. Possibly in this sinking in a motor area and the absence of the same in the sensory areas, we have a suggestive difference in the reactions of the several portions of the cortex.

"Finally, the deficiency was not so very great even in those areas, where it was most marked, and the question arises as to what sort of occupation the cells in those areas had, which would thus justify their prolonged existence. If they were thrown entirely out of function it is not easy to see how they could last so well for nearly sixty years. In some way then they may have taken a slight part in the cerebral activity, but it was so slight that their specific reactions did not rise into consciousness, for though Laura had some light perception up to her eighth year, she apparently had no visual memories, whereas those who have retained full vision up to four and a half or five years of age and then become blind, do usually remember in terms of sight."

On the Mammalian Nervous System, its Functions, and their Localization Determined by an Electrical Method.[1]

The memoir bearing the above title is the most important contribution to that department of experimental neurology established by Fritsch and Hitzig which has appeared for some years. An outline of the work was published in the Proc. Roy. Soc., Vol. 45, 1889, but it is here given in great elaboration with full illustration. After some pages devoted to introductory and historical matter, a detailed description of methods, anæsthesia, apparatus, and precautions, the following topics are discussed:

The resting electrical difference in the Mammalian nerve and spinal cord.

The electrical effects evoked in the spinal cord and mixed nerve by excitation of the cortex cerebri.

The electrical effects evoked in the spinal cord and mixed nerve by excitation of the corona radiata. Bilaterality of representation as evidenced by the electrical changes in the spinal cord and mixed nerve.

The electrical effects evoked in the spinal cord by localized excitation of its different parts.

The electrical effects evoked in spinal cord by excitation of the lumbar nerves.

The electrical effects evoked in the lumbar nerves by excitation of the cord.

The functional activity of the nerve centres in the spinal cord and their relations to nerve fibres.

The electrical effect evoked in the spinal cord and mixed nerve by absinthe and strychnia.

The point from which the investigation proceeded is indicated in the following clause in the introduction: "It was reasonable to presume, if the cortex were discharging a series of nerve impulses at a certain rate down the pyramidal tract, that there would be a series of parallel changes in the electrical condition of the fibres in the cord tract, and that with a suitable apparatus for responding to such changes these might be both ascertained and recorded."

The only instrument available for the task is Lippmann's electrometer.

In employing ether, the anæsthetic was pushed until profound narcosis ensued with the purpose of avoiding the depressing effect of

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[1] Croonian Lecture, Phil. Trans. 1891, By Francis Gotch and Victor Horsley

shock. During the period of observation after operative procedure was finished the narcosis was gradually diminished.

Summary: The resting electrical difference between the cut and uninjured longitudinal surfaces of the mixed nerve is .01 Daniel (cat) or .005 Daniel (Monkey), in the case of nerve root, or .025 (cat); in the case of cord, .032 (cat) or .022 (monkey). The difference in the cord is increased during its function and is more pronounced when it is connected with encephalon.

The excitatory state evoked by cortical activity undergoes a diminution of over 80 per cent. in the passage from the cord into the sciatic nerve.

By applying the galvanometric method to differentiate the cortical excitable areas, by comparing the discharges from the same in the spinal cord, a striking degree of localization was demonstrated.

The effect of excitation of the corona radiata on the cord is only half that of the cortex and the effect in the sciatic is but one fourth that of the cord. It is possible to produce strictly unilateral effects in cord and sciatic nerve from complete excitation of cortex cerebri and corona radiata, but the circumstances which favor *bilateral* effects are such as bring into play the opposite hemisphere, cerebellum, basal structures, etc. The normal condition is unilateral.

In the monkey a relatively larger number of direct fibres are contained in the lateral column than in the posterior, while in the cat the reverse is the case.

For both classes of impulses and animals observed no evidence was obtained of crossing between lateral columns but evidence of indirect connections between one posterior column and the lateral column of the same side, and evidence of cross connections between the posterior columns. There is no evidence of any continuous fibres between the mid-dorsal and lumbar regions.

By far the majority of afferent impulses ascend the cord on the same side as the root, a small minority ascend by the posterior column of the opposite side. The direct path is in the posterior column of the same side, the indirect paths in the posterior columns of both sides and the lateral column of the same side.

Descending electrical effects occur as follows: On minimal excitation of the posterior column, impulses are directly transmitted into the posterior roots of the same side and so into the nerve. On maximal excitation, impulses are transmitted by indirect paths across the posterior roots of the opposite side, though some impulses are indirectly transmitted to the root of the same side.

On excitement of the lateral column, impulses are indirectly transmitted to the mixed nerve of the same side as that of the excited column.

There is a complete obstruction to all centripetal impulses which may reach the cord by the central end of the anterior root.

Whenever a spinal centre discharges, nerve impulses pass from it down the posterior roots as well as the anterior. [If this be substantiated we have an important suggestion as to a possible influence of activity of the body upon its growth—trophic problem.—ED.]

The volume will doubtless prove a stimulus to further investigation in this promising field.

SOME RECENT RESULTS OF GOLGI'S METHOD OF SILVER-CHROME IMPREGNATION.

In accordance with an earlier promise, a brief account of this celebrated method is introduced as preliminary to our own observations.

On the 25th of January, 1842, a savant justly celebrated for his epoch-making studies upon the structure of the nervous central organs succeeded in making thin sections with a scalpel from a bit of spinal cord which had been frozen at a temperature of 13° R. Says Stilling, "When I first placed the section under the microscope, and viewed, with a power of 15 diameters, the beautiful transverse striations (central nerve tracts), I had found the key which would reveal the mysteries of the wonderful structure of the spinal cord. Archimedes himself did not cry 'Eureka!' with more enthusiasm than I did at the first sight of these fibres."[1]

But, as Van Gehuchten well says, "Malheureusement, la clef trouvee par Stilling n'ouvrait que le vestibule et, pendant cinquante annees, nous avons du faire antichambre."[2]

It is perhaps too early to admit with the author just quoted that Golgi's method is almost perfection, that "c'est un veritable passepartout qui nous ouvrira toutes les portes", but it certainly affords a means of isolating certain (or unfortunately at present, uncertain) elements in the central organ with the most diagramatic distinctness.

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[1] See EDINGER, Lectures on the Central Nervous System, 1889, p. 3.

[2] Les Decouvertes Recentes dans l'Anatomie et l'Histologie du Systeme Nerveux Central. Brussels, 1891.

We have already given an epitome of the results of Golgi and Kölliker [1] and refer the reader to the list of papers beyond. A very convenient summary is given by A. Van Gehuchten in the work referred to above, while his own results are elaborated particularly in La structure des centres nerveux la moelle epiniere et le cervelet, *La Cellule*, VII, 1. 1891.

The shorter method introduced by Golgi and generally followed consists in the precipitation of chromate of silver in the tissue in accordance with the varying susceptibility of the parts. It will be self-evident that embryonic or at least young specimens will possess an advantage in the latter respect over older and less permeable tissues. The procedure is as follows: Small specimens of the tissue, 3–6 mm., are placed in 2 per cent. bichromate of potash for 4–5 days and then for 24-30 hours in a mixture of 2 parts one per cent. osmic acid and 8 parts 2 per cent. bichromate, and finally in 0.75 per cent. nitrate of silver solution. Acording to Dr. Sala, Golgi's assistant in Turin, the various modifications since introduced offer slight or no advantage over this simple process. Van Gehuchten, on the other hand, claims that the addition of a small amount of formic acid (one drop to 100 cc. of the silver solution) favors a proper reduction. In this solution the specimen remains several weeks without injury, provided there is sufficient fluid and it be kept in the dark.

Although Sala regards the cutting of fine sections with the microtome and the paraffin imbedding process described by Sehrwald as an entirely useless refinement, he nevertheless indicates a method of attaching the specimen to a cork with gum arabic and sectioning with the microtome under alcohol. Van Gehuchten passes the specimen from silver to 96 per cent. alcohol for 20 minutes, then into absolute alcohol for 15 minutes, after which they remain in dilute solution of celloidin, which is hardened in 70 per cent. alcohol. From the latter in an hour or so they may be removed to the microtome. The sections are placed for an hour in silver nitrate solution, thence they pass into 96 per cent. alcohol, then into creosote, are cleared in turpentine and mounted in dammar in benzole. It is recommended to hasten the evaporation of the benzole by placing in a drying oven.

Fusari obtained his beautiful results by the use of Müller's fluid followed by a mixture of that fluid with osmic acid in varying proportions

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[1] Journ. Comp. Neurol, March, p. i-ii., p. 95-99; June, p. 197-199; also in the Bulletin of Denison Univ. Vol. V.

and for varying time (four-fifths Müller's fluid and one-fifth osmic acid 1 per cent. for one to two days, followed by three-fourths per cent. nitrate of silver).[1]

The proportions of bichromate of potash and osmic acid may vary considerably. In some cases it is preferable to place the tissues directly into a mixture of 4 parts 3 per cent. bichromate and 1 part 1 per cent. osmic acid, though what little experience we have had favors the previous partial hardening in 3 per cent. bichromate of potash.

It is unnecessary to recapitulate the results given in Van Gehuchten's paper already alluded to, for they constitute, in the main, a repetition of the facts summarized in the first volume from Prof. Kölliker's papers in the Zeitschrift f. wissensch. Zoologie.

The point of greatest theoretical interest connected with the recent applications of Golgi's method is the light thrown on the problem of the transferrence of nervous excitement. Instead of direct translation of nerve stimuli through continuous paths we are to conceive of a radiation or induction through a more or less resisting or impervious medium. Instead of nervous continuity, we have at most nerve contact or propinquity as a condition of discharge. Thus a distinct physical basis is afforded for the resistence theory of reflex action. Plate XI, Fig. 1, from VanGehuchten, illustrates the conditions for voluntary motion. The impulse generated in a cortical cell (*a*) passes via the axis-cylinder process by either a direct or crossed tract in the cord to the vicinity of one of the radical cells of the ventral cornu with which it is more or less closely connected by means of so-called collaterals. A single cortex cell may be associated with a number of the motor cells of the cord. Simple reflex action is explained by Fig. 2 A, in which (*a*) is the sensory root giving off collaterals which divide into minute fibrils about the motor cells of the anterior cornu. In other cases, by means of the fibres of the ascending columns and their collaterals the excitement is carried for a greater or less distance cephalad, finding exit through the motor collaterals in regions above that excited. Fig. 2, B. Still again, the collaterals of the excited fibre, by contact with numerous commissural cells, transfer the excitement to the ventral cornu of the opposite side. Fig. 2, C.

Fig. 3 is a diagram intended to illustrate the relations in the cere-

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[1] ROMEO FUSARI, Intorno alla fina anatomia dell' encefalo dei Teleostei. Atti della R. Acc. dei Lencei cl. fis. ecc., 4a, Vol. IV.

bellum, which is supposed to be cut longitudinally with the different elements drawn separately in the different portions. A correct view would necessitate the superposition of the several portions upon each other. A represents two Purkinje cells with their axis-cylinder processes passing into the central white layer, B, large stellate cells of the molecular layer, C, large stellate cell of the granular layer, D, granules or small stellate cells of the granular zone, E, neuroglia cells. The small stellate cells of the granular layer are said by Cajal to possess small branching processes as well as axis cylinder processes which pass to near the surface of the molecular layer and there bifurcate. The basket-like projections from the axis-cylinder (?) of the large cells of the molecular layer are well seen in the figure; they envelope the body of the cells of Purkinje.

Van Gehuchten summarizes his results on the olfactory as follows: "In mammals the lateral cerebral ventricle is prolonged into the olfactory bulb. The ventricle is lined with an epithelium similar to that of the spinal cord. In the lower part of the figure (Fig. 4.) the mucous olfactory layer is represented (*mu*). In this layer I find, in harmony with Cajal, two sorts of cells,—epithelial cells (*ce*) and bipolar cells (*cb*). The latter are the nervous elements with an axis-cylinder process (olfactory fibre) which traverses the submucous layer and cribriform plate of the ethmoid and terminate in free fibrils within the glomernles The same glomerule receives a protoplasmic process from a large cell called from its form *mitral* cell. The protoplasmic process terminates in the glomerule with free fibrils. The body of the cell gives off numerous other protoplasmic processes and an axis cylinder extending toward the cerebrum! This is therefore another illustration of the transmission of nervous stimuli by contact. It will be observed that this description distinctly departs from the view that the axis cylinder alone is of a nervous character. The writer has called attention to the fact that the glomerule is a station where the nerve path losses its integrity by the fusion of the sheath and has suggested that it may be a point for the elaboration of new material, as indicated by the great number of Deiter cells and nutrient bodies collected about the glomerule. It is not impossible that the fibrils demonstrated in the glomerule may sustain some such intrerpretation and that a delicate, if undemonstrable, connection exists between the mitral cells (specific olfactory cells) and the processes of the epithelium. In general, this scheme for the olfactory is hard to bring into accord with the view lately advocated that the olfactory pero is not an integral part of the brain but an ingrowth from without.

With reference to the function of the so-called protoplasmic processes we quote from Van Gehuchten as follows: "This example of nervous transmission by contact afforded by the olfactory bulb is interesting from another point of view. It casts, in effect, a bright light on the physiological role of the protoplasmic processes of the nerve cells. According to Golgi, these prolongations come into intimate relation with the blood vessels and serve solely for the nutrition of the nervous elements and have no share in the transmission of a nerve stimulus. The latter function pertains solely to the cell body and axis-cylinder processes, which Golgi accordingly designates as the functional processes. Ramon y Cajal opposed this view; the structure of the olfactory bulb indicates clearly that the protoplasmic processes communicate with the axis-cylinder processes. Kölliker has not discussed this question. We have verified all the statements of Ramon y Cajal, and we admit with him that the whole nervous element is active in the transmission of the stimulus, the protoplasmic processes and the body of the nerve cell receive the stimulus from the axis-cylinder of an adjoining cell and transmit it through its own axis-cylinder to other nervous elements. The absolute independence of the nervous elements and, as a natural consequence, the transmission of nerve stmuli by contact is thus verified in all the various parts of the cerebro-spinal axis." [1]

Until quite recently the application of Golgi's method to invertebrate tissues has proven unsuccessful. But hand and hand with the development of the methyl blue *intra vivam* staining introduced by Erlici, which has afforded such wonderful results in the hands of Retzius, has gone the application of the silver method to the nervous tissues of lower animals. A beautiful illustration of the connection between the most widely separated regions of comparative anatomy is afforded by the results obtained by Lenhossek with Golgi's method applied to the earth worm. [2]

The author summarizes his results as follows: "The sensory nerve cells, i. e., those elements which correspond to the spinal ganglion cells of vertebrates and give rise to the sensory peripheral fibres are found neither

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[1] Les decouvertes recentes dans l' anatomie et l' histologie, etc., 1891, p. 41.

[2] MICHEAL VON LENHOSSEK. Ursprung, Verlauf und Endigung der sensibeln Nervenfasern bei Lumbricus. Archiv f. Mikroskopische Anatomie, XXXIX, p. 102—136. Plate V.

in the spinal cord nor in special ganglia but in the skin, of which they form a part. The sensory fibers originate in the integument, thence they pass to the cord, the dendritic mesh-work of which they penetrate. Here they bifurcate forming a descending and an ascending branch as in vertebrates; these branches pass strictly longitudinally and terminate free in the next ganglion. The individuality of the fibre is not lost and but few if any lateral branches appear. Each sensory fibre comes into connection with three ganglia, the ganglion of entrance and that cephalad and caudad of it."

Thus we find in the invertebrates the real clue to the distinction between motor and sensory cells and the explanation of the pregnant discovery of Professor His, already referred to in this journal, that the sensory fibre develops centripetally and the ganglia arise from a distinct epidermal embryonic anlage. The sensory cells were primarily scattered over the body in a more or less heterogeneous manner and their processes were distributed to the spinal nerve centres after the manner of the neuromuscular processes of Hydra. The formation of sensory ganglia is a late acquisition and what was once a unipolar cell becomes by reason of its retreat from the surface bipolar.

It should be added that the application of the Golgi method is not necessary to make out these relations. Prior to the appearance of this paper Mr. Turner, at my suggestion, applied the sublimate modification of the hæmatoxylin stain to the staining of sections of Lumbricus and we were able to make out even in quite thick and imperfectly hardened preparations the peripheral nerve cells and termini. It is my impression that they are much more abundant cephalad and differ in no way from the beaker-masses in the pharyngeal cavity where they are very abundant. The accompanying figures will make the relations obvious. (See Plate XI.)

Fig. 5, is a section through the epidermis with impregnated nerve cells. The mucous cells are large and supplied with pores while the nerve cell is slender with a basal process. A capillary loop enters the epidermis. *Fig.* 6. Part of a cross-section, *a*, epidermis, *b*, concentric muscles, *c*, longitudinal muscles, *d*, spine, *e*, cephalic root of a double nerve, *f*, cross section of ganglion with an impregnated motor cell.

Fig. 7. Horizontal section of ventral nerve cord to show the course of the sensory nerve-fibers.

The application of the Golgi method to the cerebellum has been attempted by Fusari in the case of the Teleosts and the results are displayed in the composite diagram copied in Fig. 8, Plate XI. The statements of this author are discussed in connection with the editor's paper on the Brain of Fishes in the present number.

THE LAW OF PSYCHOGENESIS. [1]

The following paragraphs, which suffer somewhat from the omission of the context, will serve to throw additional light on the difficult subject discussed by this lucid writer in the last chapter of his "Animal Life and Intelligence" noticed in the February number.

Is there a law of psychogenesis? Is there a common principle which sweeps through the whole range of mental evolution, alike in the individual and in the race? A principle sufficiently general to cover the whole field of consciousness, and yet not so vague as to be meaningless? I believe that there is such a principle; one which applies alike to the simpler inferences of perceptual experience, and to the more complex judgments in matters intellectual, æsthetic, moral. I shall here endeavor to indicate its nature.

The Role of Consciousness. Without attempting to enter upon such vexed questions as, What is consciousness? and, What is its relation to man as an organism? I think we may say without much fear of contradiction that the business (or, shall we say, part of the business?) of consciousness is the control of action. If it be not so, if consciousness has no such guiding and controlling power (however exercised), then it is but a by-product; very beautiful and precious, no doubt, but none the less a by-product, an epi-phenomenon, a mere incident and not a factor in the development of organic life. Then is all organic response and conduct brought down to the level of reflex-action. . . . There is a tendency among certain nerve-physiologists to regard all organic response as of the nature of reflex-action, the differences being only differences of complexity. I strongly suspect, however, that this procedure ought to be reversed, and that we ought more clearly to distinguish between the involuntary reflex-act, properly so called, and a response under voluntary and conscious control. . . . When I say then that the role of consciousness is the control and guidance of action, I do not mean consciousness as dissociated from the living organisation, but consciousness as associated with, and forming the mental

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[1] Extracted with the permission of the author from an article in Mind, New Series, Vol. I., No. 1.

aspect of certain transformations of energy in the brain or other organ of control. . . . As Prof. James has said: "If a brief definition of ideal or moral action were required, none could be given which would better fit the appearances then this : "*It is action in the line of greatest resistance*". How comes it to appear to be action in the line of greatest resistance? Because of the sense of effort which is associated with the final decision. Now this sense of effort most markedly accompanies the newest and most difficult activities; it is distinctively associated with the higher control-centres. Whatever be the psychology of effort, its association with the higher control is a fact of common experience. Suppose that we are drawn towards some natural but immoral action by our lower instinctive impulses; but that we resist the action by a resolute act of will, in obedience to the prompting of a moral ideal. It is the latter and not the former, the ideal motive, not the natural propensity, that is a matter of our control centres. *We identify ourselves rather with the action of our control centres than with our lower animal instincts,* and say that *we* prevail over the instinctive propensity. This association of the idea of self with the higher and most individual control-centres, as compared with the lower instinctive propensities, is the basis of a rational doctrine of free-will. These higher impulses of the individual control-centres we regard as essentially our own, we regard as voluntary; and we associate with them the motor feelings of effort which accompany the newest, most difficult, most individual activies. A rational doctrine of free-will (which may be held by the most rigid determinist) asserts that the acts we call voluntary are essentially our own, the outcome of the play of our own control-centres; and that, being ours, we are responsible for them. . . . All that I wish to insist upon is that the external occurrences *must be translated into consciousness* ere they can become part of the symbolic series. . . . It is with the object as part of the mental symbolism that we are dealing in all cases of human preception and observation. . . . I have laid special stress upon the symbolic nature of perceptual experience, because it is sometimes supposed that in psychogenesis we have to try and explain two things: first, the relations of percepts to each other and to concepts; and, secondly, the relations of percepts to objects perceived or external occasions of perception. If what has been urged above is valid, these two things are so radically distinct and different that we should not comprise them under one head, at least without a very clearly distinguishing adjective. We may call psychogenesis within the sphere of mental symbolism "positive psychogenesis," and reserve the term "metaphysical psychogenesis" for the further and totally distinct question of the relationship between the symbolic series as a whole and its external occasion. It is with positive psychogenesis that I deal.

Psychogenesis and Experience. We give in general the name of experience to the process by which the individual powers of the mind are unfolded. To learn by experience is essentially a process of trial and error. The child in response to certain external stimuli, or perhaps automatically, puts forth its varying activities. Through the guidance of experience some of these actions are enforced, some checked. This, be it noted, is a matter of control Experience does not originate the activities, it guides them into suitable channels, selecting those which give satisfaction in consciousness and rejecting those which in consciousness are unpleasant and distasteful. . . . Such are the rude teachings of experience in the lower planes of mental symbolism. More subtle is the guidance in the higher plane of intellectual, moral and æsthetic control. But it is the same in principle. Conduct in these regions, however, is more idealised; less under the sway of somewhat rough perceptual inferences; more under the control of reason and conceptual thought. The experience is here more distinctly and obviously subjective. The modest woman is not pure in act through bitter experience of the results of an immoral life. She is pure in conformity with an ideal which is part of her moral nature. Just as the child avoids the fire because it hurts, so does the pure woman shrink from the thought of an immoral act because it hurts. Just as it is part of the child's perceptual nature that he should suffer from contact with certain objects, so is it part of such a woman's moral nature that she should be scorched and burnt by impure thoughts. Experience is self-knowledge. Without experience there could be no conscious selection of those activities which give satisfaction in consciousness, no rejection of those which in consciousness are unpleasant and distasteful. And psychogenesis in the individual involves such a selection among the states of consciousness which constitute the mental symbolism . . So far as organic evolution is concerned, and psychogenesis is from our point of view closely associated with organic evolution, this use-inheritence is, if established, admittedly only one factor. Another factor, regarded as dominent by most biologists, is natural selection.

Rsychogenesis and Natural Selection. I need not describe ths mode of action of natural selection. It is based upon the law of increase, the law of variation, and the struggle for existence: the law of increase, that many more individuals are born than survive to procreate their kind; the law of variation, that these individuals are not all alike; and the struggle for existence, by which those who fall below mediocrity are eliminated, while those who excel, interbreeding with average individuals, tend to rise the standard of mediocrity in the succeeding generation. A wolf-spider and his wife are cunning in their awful stalking of unwary flies. They have a numerous family. Some are inferior in cunning to their parents, some equal them, a few excel them. But flies are scarce, and there is not enough food for all. Only two can get a living, but these two are just the most cunning of the whole brood. Of the numerous family produced by these selected individuals, only two again survive to continue the race, and they the very cleverest of the lot. They have not inherited any cunning *individually acquired* by their parents, but they are terminal products of a series of fortunate variations in the direction of cleverness.

It is clear that there is no inherited experience here. The relation of this process of natural selection to experience seems indeed to be this. Learning by experience in the individual is a process of trial and error, erroneous response being checked. Learning by experience in the race is also a process of trial and error, individuals who failed to accommodate themselves to their surroundings, as the result of their individual experience, being eliminated. In the one case erroneous responses, in the other erroneous respondents, are eliminated. There is no inheritance of experience, on the view above indicated, but those individuals who best profit by experience are selected and transmit their ability so to do.

Now what is the relation of natural selection to psychogenesis or the development of mental symbolism? If we say that it has been a factor and a most important factor in its development, we must be clearly understood to mean by developement, guidance along certain lines, not origin or initiation. Though the struggle for existence may have caused the elimination of these individuals in which the mental symbolism was relatively imperfect or deficient, natural selection does not give us the law of its internal development.

What is the function, if one may so say, of the mental symbolism in the animal world? To enable the organism so to guide its actions as to resist elimination, to live out its full span of life, and to procreate its kind. Those organisms in which this function is performed in the most efficient manner have survived through the operation of natural selection. Be it so. But the power of efficient control must have been *there*, given in the organism, ere it could be selected. Every advancing step in the development of mental symbolism and of the control it rendered possible must have been *presented* to natural selection, was not in any sense *evoked by* natural selection. . . .

Natural Selection and Social Evolution. Granting that natural selection is a dominant factor in organic evolution, is it also the dominant factor in social evolution? I believe that in modern phases of social evolution natural selection holds a quite subordinate place.

So much is said and written about the social struggle for existence; so largely does competition enter into all phases of social procedure; so conspicuously does the principle of selection, and election, meet us at every turn; that it may seem somewhat absurd to contend that natural selection holds quite a subordinate place in social evolution. If not natural selection, it may be said, at any rate a strictly analogous process is not subordinate but dominant.

Is the process strictly analogous? I think not. What is the method by which progress is secured by natural selection? The elimination of failures, that is to say of all those individuals who fall below mediocrity, or their exclusion from all participation in the continuance of the race. Is this true of social evolution regarded as a whole? Are the failures eliminated? Are they excluded from all participation in the continuance of the race? Do not the social problems of the day largely arise out of the fact that the social failures are *not* eliminated but are here in our midst, and that they multiply exceedingly? Are not the checks to increase of population mainly prudential? And are not the prudent—those who look before they leap into marriage—for the most part those who are *not* social failures? It is just because natural selection, or the elimination of the unfit, is not and cannot be the law of development in a civilised social community, that we are surrounded on all sides with the most difficult social problems.

Or look at the matter from a slightly different standpoint. No account of social evolution would be complete which did not comprise a consideration of progress in Art, Science, Literature, Morality. Now I do not believe that anything analogous to natural selection, any process of eliminating the unfit, has been the dominant factor in the evolution of any of these higher phases of social endeavour. . . .

Psychogenesis and Sexual Selection. Sexual selection then differs from natural selection in this: that whereas natural selection is a process by which is effected the physical elimination, by death or failure to procreate their kind, of those who fall below mediocrity; selective mating is the giving expression to certain preferences or ideals. By natural selection all are plucked in life's examination who do not reach a certain standard of excellence: by selective mating particular individuals are picked out by an act of selective choice. Natural selection has guided the mental symbolism to certain developments by eliminating those in whom these developments were absent: selective mating is a product of the mental symbolism so developed. It is itself the outcome of psychogenesis. And however important it may be as a factor in social development it is rather the result of than the cause of the higher phases of mental evolution.

The Law of Truth. In seeking an answer to the question: What is the law of psychogenesis? it will be well to start from the higher and more abstract region of concepts and work our way downwards to the more practical level of percepts; and then, having found certain subsidiary laws or principles, to see if there does not run through these a single basal law or principle.

What is the guiding principle of development in intellectual matters? I would call it the *law of truth*. In the course of my reading and of my converse with my fellow-men I find the facts of nature and of human conduct and experience interpreted in a number of different ways. Some of these interpretations I unhesitatingly accept as true; others with as little hesitation I reject as false; many I ignore or relegate to a suspense account. On what ground do I at once accept certain interpretations and reject certain others? It is often difficult to give, off-hand, the specific grounds of acceptance or rejection. But it practically comes to this. I accept what is in accordance with my own views and theories: I reject what is contrary to my own scheme. I relegate to a suspense account, or ignore, what neither accords fully with my system of interpretation of nature, of life and of man, nor actually conflicts with the interpretation. I neither accept nor reject what seems to be irrelevant. . . . The true is accepted, the false rejected; the rest more or less ignored. No man consciously accepts the false, or rejects the true. . . . To say that any one believes what he deems untrue is a contradiction in terms. . . .

The Law of Psychogenesis. Enough has now been said to indicate what I regard as the law of psychogenesis. As in the case of natural selection, properly understood, it is a law ef elimination—the elimination of the incongruous. It applies not only to the relations of concepts *inter se*, but to the relations of concepts to percepts, and of percepts to other percepts. It sweeps through the whole gamut of mental development. It is a law of the assimilation or incorporation of like with like. Progress is effected by the elimination of the incongruous.

Assimilation presupposes an environment of that which is capable of assimilation. And the environment in which mind develops is a mental environment. That is a fact too often lost sight of. Consciousness never comes in contact with aught but other facts of consciousness. The mental symbolism is one and continuous and self-contained. There is no getting outside it. If mind does grow up in correspondence with something that is not mind this is a matter of metaphysical psychogenesis, not of positive psychogenesis with which alone I am now concerned. From the positive point of view mind develops in conformity with a mental environment and with that alone—an environment of percepts directly suggested from without and of concepts growing out of perceptual experience or suggested through inter-communication with our fellow-men. And the environment is not unchanging, but is itself subject to development. Each thinker not only has his thoughts moulded by the intellectual environment but reacts upon it, making it for the future something different from what it was. The thinker in any department of knowledge brings his mind into contact with all that is best in human thought and endeavour in that department. He thus finds his true environment and endeavours to make it more congruous by further elimination of incongruities. That I feel sure is how science has advanced. First the congruous system is allowed to take form in the individual thinker's mind by the assimilation of all that is best in the work of his precursors; by the rigorous application of scientific method and verification some of the remaining incongruities are eliminated; and then through the thinker's influence the amended and extended system is impressed on the science and philosophy of his time and of all after time. The environment is henceforward no longer the same. This I could amply illustrate; but not here and now.

The environment is henceforward no longer the same. This constant change—for the better as we hope—of the environment of the developing mind makes it exceedingly difficult, if not impossible, to test the truth of the theory of use-inheritance, already adverted to, in the matter of the mental faculties of man. . . . It will of course be observed that in contending that the law of psychogenesis is a law of development by the elimination of the incongruous, I am not pretending to account for the origin of the congruous. Just as natural selection accounts for organic development by the elimination of the unfit, but makes no pretence, or should make none, to account for the origin of the fit (which is a distinct problem), so do I suggest that natural development results from the constant elimination of the incongruous; but I make no pretence that it accounts for the origin of the congruous. It is a theory of survival, not of origin. —PROF. C. LLOYD MORGAN, Univ. College, Bristol.

ORIGIN OF THE ACOUSTIC NERVE. [1]

Summary. 1. Deiters', the dorsal, and Bechtegrew's nuclei are not niduli of origin of the acoustic, and the cells belong to Golgi's first type which apparently send fibres into the formatio reticularis.

2. The ventral nidulus and the tuberculum laterale are centres of origin, the former for the anterior, the later for the posterior portion.

3. The ventral nidulus consists of two sorts of cells, the central portion containing cells similar to centers of origin of nerves, the peripheral elements resembling cells of the spinal ganglia. The former give rise to processes which subdivide in the neuropilem from which the nerve springs, while those of the latter attach themselves at right angles to the root fibres.

4. From the latter sort also arise fibres which pass fram the ventral nidulus to the corpus trapezoides and reticulum of the superior olives.

5. The posterior root of the acusticus arises by most of its fibres (striæ acusticæ) from the tuberculum laterale, a few being derived from the ventral nidulus.

7. In the anterior root there are fibres from the corpus restiforme.

7. The peripheral part of the ventral nidulus may be regarded as a true spinal ganglion.

8. The nervous elements are, as Golgi stated, in direct anatomical continuity with each other.

METAMERISM OF THE HEAD. [2]

McClure describes the primitive vertebrate brain as composed of a series of segments similar to those which have been identified in embryonic cord and sustaining a similar (i. e. intermediate) positon relative to the provertebræ. The segmental nature of the brain is indicated by a series

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[1] L. SALA. Sull' origine del nervo acustico.

[2] Journal of Morphology. The Segmentation of the Primitive Brain, 1890.

of symmetrical folds originating cephalad. Each of the neuromeres gives rise to a pair of sensory nerve roots. The mesencephalon supplies the third and fourth nerves. There are six brain segments in the metencephalon and two in the primary prosencephalon, making ten in all, agreeing with Von Wijhe's view that there are nine cephalomeres.

DORSAL LONGITUDINAL FASCICULUS. [1]

The dorsal longitudinal fascicle is strongly developed in turtles, forming two strong protuberences in the fourth ventricle, and may be followed distinctly through the whole cord. It lies dorsad of the ventral commissure. It consists of large fibres, among which, in the caudal region, is a large cord like the Mauthner fibre of fishes. In the medulla there is a combination of the large-fibred fascicle, which is distinct in the cord, with the dorsal longitudinal fascicle. These two bundles together represent the Müller's fibres or, in general, the large fibres of the lower animals.

THALAMUS. [2]

Nissl distinguishes a number of niduli in the thalamus of the rabbit. The method was alcohol hardening and staining with basic analins. The cephalo-ventral nidulus is divided into a dorso-mesal and a ventro-lateral portion. Mesad from this anterior nidulus is the small meso-cephalic nidulus, which lies like a cap on the meso-median nidulus. The latter lies close to the median line and may be followed half the length of the thalamus. Ventrad of the anterior nidulus is the nidulus of the lattice-layer, "Kern der Gitter Schicht," close upon the median line lies the nidulus of the median line. The cephalo-lateral nidulus which lies in the lateral protuberance of the thalamus, occupies nearly two-thirds the length of the thalamus and consists of the largest cells. Mesally it impinges on the large meso-caudal nidulus. Between the ventral and dorsal lattice nidulus is the very large ventral nidulus, which occupies about the posterior one-half of the length of the thalamus. In the ventral nidulus the lateral group contains spindle-cells, the median contains large cells and the dorsal small ones.

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1. Koeppen, Tageblatt d. 62 Versamml. deutsche Naturf. u. Arzte in Heidelberg.

2. Die Kerne des Thalamus beim Kaninchen. Tageblatt der 62 Versammlung deutscher Naturf. und Arzte in Heidelberg.

The ventral nidulus forms a triangle the base of which rests upon the lamina medullaris interna. Between the latero cephalic nidulus and the corpus geniculatum externum lies the caudo-lateral nidulus.

In the ganglion habenulæ there is a lateral and median nidulus. Between the two lateral niduli and the ganglion habenulæ lie the lateral and meso-caudal niduli. The corpus geniculatum externum consists of a dorsal nidulus with a distinguishable dorso-lateral portion. The ventral nidulus of the corpus geniculatum may be separated into a ventro-mesal and a ventro lateral portion.

Præcommissura.

Rabl Rückhard [1] in a mature foetus of *Xenurus gymnurus* discovered a strong tract from the anterior capsule to the external capsule.

Torus Longitudinalis.

Rabl-Rückhard identifies a longitudinal ridge from the ependyma of the Sylvian aqueduct of *Xenurus* (Edentata) as the homologue of the torus longitudinalis of fishes.

Neuroglia.

According to Weigert, the neuroglia fibres form a dense reticulum upon the surface of the central nervous system. In the cerebrum the reticulum is present in the white matter and superficial layer, while the deeper parts of the cortex are comparatively poor in neuroglia fibres.

Lachi states that in the chick up to the 8th or 9th day there is an ectodermal neuroglia (of spongioblast origin) but mesodermal elements then appear forming the pia and sinking into the white substance. These gradually reproduce and take the place of the spongioblasts. After birth leucocytes and endothelium cells are superadded. Staderini states that the granular substance found by Thompson at the exit of various cerebral nerves and which Thompson regarded as degenerate nerve cells are easily recognized in the 3d, 4th, 6th, 7th and 10th nerves but really consist of projections of the central neuroglia with which they retain connection.

Microcephalic Deformity.

The past twenty months have exhibited a great deal of progress in the study of these interesting modifications.

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[1] Einiges Meber das Gehirn der Edentata. Archiv f. mikr. Anatomie, XXXV. 1890.

Giaconini [1] formulates the following statements :

1. Microcephalism is essentially located in the central nervous system. 2. The deformity of the skull is a result not a cause. 3. The disturbance is not limited to the brain but extends to other parts of the nervous system. 4. Microcephalism consists in a retardation in the development of the central system, beginning at various periods. 5. The nervous system exhibits no pathalogical condition explainable as a result of complete arrest of the development. 6. The brains of microcephalic subjects exhibit all the stages of human brain development from the earliest on. 7. In the structure of the surface there are modifications which must be referred to atavic reproduction of conditions of the brain of lower animals.

The work of Marchand given in the literature furnishes illustration of the above points. An abnormal development of the callosum is very common, the curtailing of the length being associated with modifications of the fornix. In the absence of the callosum the median fissures, etc., are radially arranged The frontal lobe usually exhibits three well-marked fissures even in extreme cases.

Mingazzini describes in the *Internation. Monatschrift f. Anatomie u. Physiologie*, VII, 5, an interesting brain from an 11 months idiotic child in which there were abnormal convolutions, absence of the callosum and præcommissure ; rudimentary septum pellucidum ; atrophy of the left tuberculum anterior of the thalamus, ganglion habenulæ, both quadrigemina; absence of fornix commissure and olfactory tract ; atrophy of the left hemisphere of the cerebellum, left inferior olives, clava, tuberculum rolandi and eminentia acustica ; reduction in the left optic tract and left pons peduncle, etc.

Mingazzini and Ferraresi take the occasion afforded by the description of an ape-like brain of a 16 years microcephalic child to distinguish two types of such abnormalities: 1, reductions in the size and simplification of structure without loss of the human type, 2, those in which there is an obvious approach to the structure of the brain of lower apes or the carnivora.

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[1] Studio anatomico della microcefala. Reale Accad. di medicina di Torino, 1890.

THE SYLVIAN FISSURE AND ISLAND OF REIL.[1]

A careful description of three brains of the Gibbon with one plate is introduced by a historical review. The author considers that his results confirm Turner's view "that the Island of Reil, which in the brain of the ape and still more in that of man is entirely concealed within the Sylvian fissure, is the homologue of the sylvian convolution of the carnivorous brain."

ACTION OF BACTERIAL PRODUCTS ON THE VASO-MOTOR CENTRES.

In the Bacteriological World of March, 1892, is an abstract of Burchard's paper before the French Academy in which it is suggested that certain bacteriological products in inflamation serve to modify its essential element, diapedesis (the passage of leucocytes through the vascular walls) by their effects on the vaso-constrictor and vaso-dilator nervous centres respectively. Massad and Bordet think that the attraction by bacterial products on leucocytes is sufficient to make them migrate through their vascular walls. But Burchard believes that the substance anectasine paralyses the vaso-dilator centres thus preventing inflamatory congestion and inflamatory œdema and also diapedesis.

THE BRAIN OF ICHTHYOPHYS.[2]

Dr. Burkhardt, assistent in Prof. Oscar Hertwig's laboratory in Berlin, availed himself of the opportunity afforded by the reception of specimens of the rare amphibian, *Ichthyophis glutinosus* from Cylon, to examine critically previous descriptions of the brain and has described the microscopic structure the central organ as well as the peculiar olfactory organs. The method of reconstruction from serial sections was resorted to. For young amphibian larvæ the author recommends preservation in Rabl's fluid and staining in alum cochineal. For older larvæ, chromic acid 1 %, 10 hours, acetic acid 5 % 24 hours, alcohol gradatim, and staining as before, or osmic acid ½ % 5 hours, careful washing and staining with Delafield's hematoxylin. Adults were decalcified in a mixture of chromic and nitric acids and cut *in toto*.

From among a number of interesting results we select the following: The optic nerve in the embryo of these blind subterranean animals is at

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1. WALDEYER, W. Sylvische Furche und Reil 'sche Insul des Genus Hylobates. Mat. u. natw. Mitth. Akad. Berlin, March, 1891.

2. RUD. BURCKHARDT, Untersuchung am Hirn und Geruchsorgan von Triton und Ichthyophis. Zeitsch. Wis. Zool., LII, 3.

first of considerable size and is hollow, as is the case throughout life in *Necturus* and *Proteus*. Soon a degeneration takes place which continues until a mere thread remains and the lumen entirely disappears. From the comparison Burckhardt infers that the accommodation to a dark habitat is phylogenetically much earlier in *Proteus* than in *Ichthyophis* in which the larva may have functional eyes.

The meroblastic development of the Ichthyophis permits the development of the head in a way more nearly like that of higher vertebrates than is the case in other and especially holoblastic amphibians. The cephalic flextures are specially well developed although they afterwards become obscured.

Among the results of particular interest is the identification of Jacobson's organ with a special branch of the olfactory as in reptiles. The paper is accompanied by two plates.

THE INNERVATION OF THE ELECTRIC ORGANS OF FISHES.[1]

In the *Mormyridæ*, which Prof. Fritsch has specially studied in Egypt, the innervation of the caudal electric organ is not via the lateral line nerve but by means of special electric nerves which emerge as spinal roots from the spinal cord and form a dorsal and ventral axial trunk. After seeking in vain for the origin of these fibres for some time it was discovered that the electrical nerve-fibres arise as broad undivided axis-cylinder processes of gigantic ganglion cells which in spinal regions completely fill up the gray substance of the spinal cord and emerge through the anterior roots. What is of particular interest just now is the fact that the protoplasmic processes of these large cells anastamose with each other forming an "eng geschlossenes, wahres Gerüst, und erscheinen zu gemeinsamer Arbeit verbunden." This affords a new evidence that the separation of protoplasmic and nervous processes is artificial as claimed by more recent followers of Golgi. The electrical nerves form a remarkable chiasm outside the vertebral column so that the left electric organ is partly innervated from the right side and vice versa.

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1. FRITSCH, G. Weitere Beitrage zur Kenntniss der Schwach Electrischen Fische. Mat. u. naturw. Mitth, Berlin Akad, Nov., 1891, p. 439. Figures in text.

Regions and Convolutions of the Prosencephalon.

It may be remarked that the writer's suggestions respecting the distinctness of the basal part of the cerebrum, (that portion beneath the rhinalis fissure) were quite independent of similar suggestions made by Prof. W. Turner[1] and, being derived from studies in very different regions serve to supplement the latter in various ways. According to Turner, in all vertebrates it is possible to distinguish a basal region or rhinencephalon and a dorsal or pallium which are separated by the rhinalis or ectorhinalis fissure. The rhinencephalon consists of the bulbus and crus olfactorius and the lobus hippocampi. The latter is always to be distinguished and is bounded internally by the fissura hippocampi and cephalad by the fossa Sylvii. The present writer has shown that the distinction between that portion of the cerebrum ventrad of the rhinalis fissure and the mantle portion is not only constant in lower vertebrates but that the infrarhinalis region is different histologically. There is serious objection to the application of the term rhinencephalon to this entire region, first, because it has long been applied to the olfactory tuber; second, because there are included cortical connective and peripheral structures under one head. If, on the other hand, the writer's views as to the essential discreteness of the pes and pero olfatorii are correct, the pero and the hippocampal lobe are more intimately associated than the pes and pero and it remains to be seen if the latter is not in reality but a ganglion on the olfactory nerve (radix lateralis). Much interesting matter on the convolutions is contained in the paper referred to. Ziegen who has also made a special study of the convolutions[2] comes to quite different results, especially with reference to the homologies of the convolutions in carnivora.

The papers of Cunningham quoted in our literature give especially interesting data respecting the transitory fissures which appear early (only in the Primates) and persist until the fourth month when they either disappear or merge more or less completely into the definitive fissures. On the lateral surface only the parieto-occipital and calcar are permanent. These fissures are variable and asymmentrical.

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[1] The convolutions of the brain. Journal of Anat. and Phys. Oct. 1890.

[2] Zur Vergleichenden Anatomie der Hirnwindungen. Anat. Anzeiger, V, 24, 1890.

THE FORNIX.

The detailed and minute work of Honnegger on the fornix is not susceptible of a compendious resume. It will remain for years the source of information in this difficult portion of the brain. Unfortunately the present work is not calculated to render the subject much more perspicuous. It may be some time before comparative and embryological data are at hand to enable us to distinguish the essential from the non-essential, the valid from the spurious, in the vast collection of facts and views here presented. There can be no doubt that many of the connections resting on observation of adult material will be shown to have a quite different significence from that now attributed to them.

THE TECTUM OPTICUM, ETC.

Cajal[1] states that in all vertebrates the optic nerve fibres terminate in free branches is the optic centra. Numerous fibres of the optic nerve, however, end in the corpus geniculatum and surrounded with their branches the cells of this body. Three categories of cells occur in the gray matter of the corpora quadrigemina, of which apparently one sort sends fibres toward the retina. (From the present writer's observations in fishes as well as the studies of Belonci in other groups it may be inferred that the fibres observed in the geniculata pertain to the inferior commissure system rather than true optic fibres). Our own observations in young fishes (see elsewhere in this number) strongly support the statements of His that the earliest optic fibres are formed as outgrowths of tectum neuroblasts whose apices pass peripherad.[2]

POSTERIOR COMMISSURE.

The studies of Edinger upon the posterior commissure and lemniscus form the subject of a preliminary notice in *Archiv f. Psychiatrie*, XXII, 1890. The posterior commissure is regarded as one of the oldest systems in the brain. The commissure of the tectum (Sylvian) is distinguished from the postcommissure.

DEGENERATION OF GENICULATUM.

Monakow has shown that destruction of the temporal lobe produces degeneration of the corpus geniculatum internum in man as well as in

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[1] Terminacion de nervo optico en los cuerpos geniculados y tuberculis cuadrigeminos. Gaz. san. municipal.

[2] Histogenese u. Zusammenhang der Nervenelemente. Arch. f. Anat. u. Phys. Supl. Band, 1890.

carnivora. Zacher finds in addition degeneration in the brachium and substance of the quadrigemina posterior.

THE NERVOUS STRUCTURES OF TUNICATES.

In a brief notice in the Johns Hopkins circulars XI, 97, April, 1892, M. M. Metcalf discusses the innervation of the ciliated funnel or dorsal tubercle and the development of the sub-neural gland in Salpa. The Salpas differ from the Ascidians in having the cavity of the central nervous system, which is present only in the early development, continuous with the lumen of the ciliated funnel. Running through the tissue of the brain, especially the dorsal two-thirds, are many ramifying canals. The ramifications of the canals often anastamose and form a free communication between the ciliated funnel and the space about the brain. They persist but a short time, the brain soon becoming solid. The author believes that the early function of the funnel was the aeriation of the brain, while it also perhaps served to carry off the waste products of the metabolism of the brain cells. The later condition, especially its innervation, indicate that the ciliated funnel is probably a sense organ, having, very likely, to test the quality of the water entering the pharynx.

At the time when the walls of the cloacal chamber begin to separate from the brain two cell masses at the point of adhesion are drawn out into tubes which become coiled and develop disc-like expansions near the brain. About these discs there develop two clusters of cells of which the anterior is composed of large cells resembling the cells of origin of the nerves while those of the other resemble the peripheral nerve cells of the brain.

THE NERVOUS SYSTEM OF GASTEROPODS.

Erlanger describes the development of the nervous system in Paludina as follows :[1]

All the ganglia originate separately by delamination of the ectoderm. Their connection is secondarily acquired by the outgrowth of commissural fibres. The cerebral ganglion originates within the area of the velum beneath the rudiment of the tentacles ; the pedal ganglia, on either side the foot ; the pallial ganglion, somewhat ventrad and caudad to the cerebral ; and the buccal from the ectoderm of the œsophagus. The intes-

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[1] R. V. ERLANGER, Zur Entwicklung von Paludina vivipara. (Vorlaeufige Mittheitung). Zool. Anzeiger, XIV, 357, Feb. 1891

tinal ganglia on the other hand, are formed on either side of the mid-body region, but, by reason of the torsional growth, one comes to lie above, the other beneath the intestine. The visceral ganglion springs from the ectoderm of the mantle cavity.

HISTOLOGICAL STUDIES IN THE NERVOUS SYSTEM OF LEECHES.[1]

Dr. Rhode comes to the somewhat startling conclusion that "contrary to the generally accepted doctrines and my own earlier views, all fibrous elements within the nerves, commissures and ganglia, and even the ganglion cells themselves are composed of non-nervous connective tissue, while the real nervous substance is a homogeneous material filling the interspaces between the fibrillæ. *Pontobdella* is most minutely described. Unfortunately the methods by which the very remarkable results are attained are not given and we are only left to infer from indications that alcoholic carmine played an important role.

NERVOUS SYSTEM OF NEMATODA.

Hamann states[2] that two sorts of ganglion cells exist in all the species examined (in contrast to Echinorhynchidæ, where only the giant cells are present). In the anal ganglion the large cells have a symmetrical uniform arrangement. The skin papillæ are typical sensory organs. A nerve can be followed into them where it expands into a large ganglion cell of complicated structure.

THE DEVELOPMENT OF THE NERVOUS' SYSTEM OF THE HOLOTHUROIDEA.[3]

At the eighth stage of development the annular and radial parts of the nervous system both consist exclusively of closely compacted cells in several layers. In a latter stage fine fibres appear beneath the cells parallel to ring-nerve, and after the 13th day irregularly scattered cells between the fibres. As early as the 8th day the median ventral nerve Anlag reaches beyond that of first pair of feet. Histologically the radial nerves, like the annular. consist of a superficial cell-layer and a deeper fibre tract which is seggregated distad, but in the latest stages examined

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[1] RHODE, EMIL. Histologische Untersuchungen ueber das Nervensystem der Hirudineen. Matur. u. Nat. Mittheil. Preus. Akad. Berlin. Jan. 1891, I, p. 11.

[2] Mittheil. Berlin Akad. Jan. 1891, p. 48.

[3] LUDWIG, HERBERT. Zur Entwickelunsgeschicte der Holothurien. Mat. u. Naturw. Mittheilungen Kong. Preus. Akad. Berlin, Feb. 1891, 2, p. 85.

the peripheral portion consists only of cells. On the 9th day the interradial nerves to the tentacles are formed, and on the 17th nerve branches arise from the median ventral nerve to the primary pedicels By the 8th day the separation of the entire nervous system from the ectoderm is complete. No indication of an auditory organ was discovered.

NEUROBLASTS IN ARTHROPOD EMBRYOS.[1]

In *Xiphidium* the nervous system arises early in the form of paired thickenings of the ectoderm. The lateral cord consists, in early stages, of small cells with elongate-oval neuclei, and four sets of larger cells with pale spherical nuclei, the latter being the neuroblasts proper. There are eight longitudinal rows of these neuroblasts. These cells proliferate and each soon surrounds a pillar of smaller elements – the future ganglion cells. The dotted substance makes its appearance in the bases of the lateral cords, which are separated by a pyramidal mass of cells, the median cord.

The median cell neuroblasts arise intersegmentally, but soon move forward between the two connectives, and finally come to lie just back of the posterior commissure of each segment. Later it is incorporated in the posterior part of the ganglion.

THE NERVOUS SYSTEM OF ECHINODERMS.[2]

The following summary is derived from the American Naturalist: "The nervous system of the star-fish is differentiated into two systems, the condensed and the diffused, between which, however, one finds it difficult to draw a sharp distinction. The functions are, however, now specialized in this large group, for we have shown that the two nervous fields have a distinct and peculiar functional aspect. Each presenting a distinct activity, they divide between themselves the work which is appropriate to the life of relation. Owing to the close connection which exists between them, the systems can aid each other and work together for the accomplishment of the multiple manifestations induced by the different conditions external and internal, by the sensations arising from stimuli, and by reaction. To the diffuse system is attributed, above all, the role of perception and of sensation. It is the one whtch gives the organism a notion of its position and which informs it of its state of equilibrum. It is

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[1] W. M. WHEELER. Journ. Morphology IV, 1891, p. 337.

[2] DEMOOR and CHAPEAUX. Tidsch. Nederland. Dierk, Vereen, III.

the one also which, accumulating those diverse and vague organic impressions, which the physiologist groups under the name "kinetic", keeps the animal in constant activity and readiness to respond to stimuli.

The motive impulses, properly speaking, the external manifestations of vital phenomena do not depend directly upon the diffused system. Their real centre is the condensed system which must then be the true organ of reactionary impulses. It is the centre in which are generated the reflex motions; it contains cell groups whose functions are definitely specialized, and which thus form the first traces of a more advanced type in which the different important manifestations of activity have become localized in distinct regions. The two nervous systems are intimately connected. The innumerable relations which unite them render their functional agreements close and each reinforces the other. From this last point of view a progressive specialization is also manifested. In fact, the conduction of excitations causing the ordinary sensations which are important only in the aggregate, is accomplished by means of the hidden fibrillæ which unite the condensed with the diffused system. On the contrary, some ways of direct communication between the two systems have been established physiologically for the special sensations before provoking a quick response, necessary and fatal. The easy propagation of sensations thus allows the corresponding motor centres to respond easily."

THE NERVOUS SYSTEM OF CRUSTACEA.[1]

Pending a more complete review of the series of which the work above quoted forms a part, we present the following memoranda from Edinger's "Bericht." From the body of nearly all ganglion cells there arises but a single axial process ("Stamm-Fortsatz") which passes directly into a commissural or axis-cylinder fibre. During its course this gives off lateral branches which pass to the dotted substance of the ganglion, where it divides into more or less numerous nodose branches without actual anastamoses or reticulum. At the anterior end of the ventral ganglia is a multipolar cell whose axial process passes into the longitudinal commissure; while processes arising in part from the axial process and in part from the body of the cell pass to the dotted substance, in which they either end in fine nodose branches or continue in the sheath of the ventral cord. Axial processes of cells pass either cephalad or caudad and may end in the

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[1] RETZIUS. Zur Kenntniss d. Nervensystems d. Crustaceen, Leipzig, 1890.

next ganglion or pass beyond it. They also form the peripherad fibres of the nerves, into which also enter fibres from the longitudinal commissures, these latter apparently derived from the axial processes of cells in other ganglia. The ganglion cells differ greatly not only in form but also in the structure of the protoplasm. The dotted substance consists essentially of the accessory processes of ganglion cells and branches from the axial fibres. The accessory as well as the axial processes must be regarded as nervous. Neither a direct origin of nerve fibres from ganglion cells without accessory processes to the dotted substance nor an indirect origin of axis-cylinders from the dotted substance occurs. Numerous details respecting peripheral nervous organs are also given. Like the other volumes of this series, this paper is richly illustrated.

MOTOR FUNCTIONS OF THE CRUSTACEAN NERVOUS SYSTEM.

J. Demoor[1] has attempted localization of the nervous system by extirpation with interesting results. Various portions of the supraœsophagal ganglion were injured by a thrust with a sharp needle without opening the thoracic walls. Four varieties of "forced movements" were produced. Rotation about the longitudinal axis, circus coursing, and somersaults were developed by injuries to various parts of the brain. The motion is always away from the injured side, proving that there is no decussation of motor fibres.

Injury to the right side of the mid-brain region produces circus motions from right to left; if farther lateral, there is rolling from right to left and then rotation in a circle in the same direction with somersaults. The authors also find anatomically that there is little decussation of the nerve termini in the central system. There is no specific function in the anterior ventral ganglion, and a destruction of the commissure connecting brain and ventral ganglia does not disturb the function of the eyes and antennæ.

TECHNIQUE AND MEMORANDA.

An extremely valuable method of composing diagrams from actual camera drawings of sections is suggested by Schaffer (*Zeitsch. f. wissensch. Mikros. VII*, 3, 1890.) The method consists in drawing the successive sections upon oiled paper which when accurately superposed and held

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[1] Etudes des manifestations motrices des Crustacees. Arch. Zool. Exper. et. Gener. IX, p. 191.

against the light show the course of longitudinal and oblique fibre tracts etc., *in continuum*. In consideration of the difficulty of drawing on oiled paper, the following suggestions are here added: The microscope is clamped upon a base which also carries a table similar to that of Giesenhagen but having a glass instead of wooden top. The paper is a very fine and tough linen paper and is made up in tablets which are firmly fixed to the drawing table. Through the tablet four small holes are punched near the corners with a needle to serve for subsequent accurate orientation. The outlines and details may be drawn in with ink quite boldly and the sheets are numbered serially and also to correspond with the sections. When the drawings are finished they are placed in sequence, orientated by passing pins through the perforations and the margins glued. The pad thus prepared is moistened with oil and becomes transparent. After thorough drying the pad can be placed upon the table and a strong light reflected from a mirror beneath enables one to produce an accurate combination sketch. Great difficulty will frequently be experienced in orientating the sections properly as there will probably be no easily recognized line lying exactly at right angles to the plane of section. Often a line due to a notch in the microtome knife serves as a guide in one direction. One may produce such a guide by plunging a hot needle through two points in the preparation while still in the block after orientating in the microtome. These needle holes should be perpendicular and parallel. This does not exclude irregularities growing out of subsequent shrinking and in this as in all methods of geometrical reconstruction the process must be "mixed with brains." It is probable that every student of sections has employed some form of this method, but its value should be recognized especially in the preliminary study of a series.

Obregia's sugar-photoxylin method of adhesion (Neurol. Centralblatt, IX, 10, 1890.) is available for series with Weigert's method and other cases where the complete integrity of a series is important. It consists in the attachment of the sections, which may be cut in ribbons if desired, on a satin paper of the width of the cover glass to be used, by a solution of sugar and dextrin. The upper surface is then flowed with a layer of photoxylin. The solution of the sugar leaves the sections attached to a film of photoxylin with which they are carried through the subsequent treatment. For securing complete section of large brains Lissauer has advised flowing the surface of the paraffin block with celloidin (or photoxylin), cutting with a knife moistened with alcohol. The various methods of attaching sections without a distinct adhesive substance seem to be untrustworthy for large or wrinkled sections. The method of attaching by arranging on a chemically clean slide and then flowing with 70 % alcohol and setting aside in a drying oven for several hours, melting paraffin and proceeding as usual, will frequently succeed, but has not proven satisfactory for series. The method of floating the ribbon upon the surface of warm water and lifting on a slide, leaving to dry in the oven, etc., is not reliable, but some modification of it, such for example as covering a long ribbon of silk paper with syrup of sugar and dextrine, permitting to dry, then floating the section ribbon on warm water, lifting them quickly on the paper band, leaving to dry, covering with photoxylin or celloidin, afterward dissolving the sugar followed by the usual after treatment, promises well.

Paladino has recommended the treatment of spinal cord after chromic acid or sublimate with a solution of chloride of palladium 1 : 1000 (slightly acidulated) for two days and staining for a day or so in 4 % iodide of potassium.

Obregia renders Golgi preparations more permanent by substitution of gold for the silver. After sections treated as usual are passed into absolute alcohol they are brought into absolute alcohol and gold chloride and fixed in 10 % hyposulphate of soda and subsequently washed in water.

A very useful variation of the hæmatoxylin method given in the December number of this journal for those cases in which the hæmatoxylin remains too distinctively a nucleus stain is the addition of a small quanity of acid fuchsin or the washing after the hæmatoxylin with very dilute fuchsin. The protoplasm is colored in cases where the hæmatoxylin fails (as in Amphibian brains). It is true that the blood vessels and the connective elements are also stained but in many cases the second stain is very useful by contrast. It is in our opinion better than carmine as an adjunct with hæmatoxylin and seems permanent.

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LITERARY NOTICES.

VISUAL CORTICAL AREAS OF LAURA BRIDGEMAN.

In the Journal of Psychology for August, Professor Donaldson discusses the data toward the location of the cerebral visual area derived from measurements of the thickness of the cortex on the two sides as compared with that of similar areas of normal brains. It will be remembered that vision in the left eye was lost at the age of two years, while that of the right persisted up to the eighth. It was assumed that the thinning of the cortex was due to an arrest of development, that this thinning would extend over the entire visual area, that, in the regions compared, the disturbance in vision was the principal influence acting to arrest unequally the growth of the cortex, that the cortex would be most thinned on the side of the brain opposite to the eye and nerve affected, and that the visual area in the normal brain gradually merges into the surrounding areas. The outline of the area thus determined is described as follows: "Commencing where the cephalic stipe of the interparietal sulcus cuts the mantle-edge and passing latero-cephalad along the latter to its junction with the inferior ventrocentral sulcus, the boundary then takes the shortest line to the ascending ramus of the first temporal sulcus, following this to its union with the sulcus from the mesal end of which an arbitrary line turns toward the fourth temporal sulcus, running parallel with this sulcus it cuts the gyrus lingualis so as to leave the ventral third of the latter in connection with the fourth temporal sulcus and continues to a point just ventrad of the cephalic end of the calcarine fissure, which it joins by an arbitrary line running dorsad, it then passes caudad along the calcarine fissure to the junction of the same with the parieto-occipital sulcus, and finally along this fissure to the mantle-edge, then cephalad along the latter to the point of departure." The author claims a close agreement with the area determined by Gowers by the method of limited lesions. "The cuneus and occipital lobe form the most fundamental portion of the visual area, hence would be earliest developed and more resistant to disturbing influences." In the outermost area the alteration is less for the opposite reason. He concludes that "in this single brain we have the entire visual area marked out." We are somewhat surprised to read in the concluding paragraph, "we have now, through the early destruction of sense-organs and the subsequent examination of the cortex, a means of experimentally determining in animals the limits of the several sensory areas. For the feasibility of this plan, the experiments of v. Gudden and his school *already offer some indirect support.*"* No doubt, however, what has already been done in this line will seem as nothing in a few years when the investigations now making are made public.

COMPARATIVE PHYSIOLOGY AND PSYCHOLOGY.[1]

Although published some years ago, we call attention to this work as one which by virtue of numerous original theories and suggestive collocations of facts from various sources deserves more attention than it may have received. The fact that its standpoint is uncompromisingly evolutionary, synthetic and monistic may make it a closed book to many. The rapid advance of neurology during the years since many of the chapters were written, has deprived some hypotheses, once very plausible, of a footing on fact.

In spite of the fact that the author's position and point of view differ widely from those of the present reviewer, the latter welcomes sincerely the effort to apply unflinchingly the data of physics and physiology to the domain of mind. So long as this is done in an honest and undogmatic way it must do good service to all interested in clearing the way and narrowing the field of discussion. The author does not hesitate to define mind as chemical affinity or an allied property of matter. Physiologically he relies upon the law that function preceeds structure. For him "association consists in mean molecular or vibratile motion," as a result of which "lines of least resistance" are produced. The following paragraphs will indicate the drift:

"Association of impressions, or the simultaneous action of two sensations in lines of least resistance, build up the filaments which go to form the sensory strands on the posterior and postero-lateral columns of the cord, and simultaneously acting motions also build up the strands of

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*Italics ours.

[1] S. V. CLEVENGER, M. D. Work by the above title, Chicago, 1885, Jansen, McClurg & Co.

the antero-lateral and anterior columns. Every nerve cell contains granule contents. The shape of the cell and the direction of the granules are determined by the composition of forces."

"Mind is located in every living cell of the body, and the better nervous association of these cells constitute grades of intelligence."

"Every impression reaching the spinal cord produces a corresponding muscular or glandular motion somewhere, unless inhibited by a secondary apparatus."

"The diversified shapes of nerve-cells seem to bear relation to the composition of forces rather than diversity of function." "The fusiform bipolar cell could result from forces traversing it; the globular unipolar, from forces terminating in it; the multipolar, from varying quantities of energy acting in several directions; the pyramidal from having its point of greatest tension at the base, with least resistance at the larger tapering process."

[Another element which we would appeal to as having a determining influence on the form of cells is their source.]

The suggestions respecting nutritive reflexes seem to us valuable, the theory of the intervertebral ganglia scarcely tenable at present, and the book as a whole, worthy a considerate reading.

THE RESULTS OF AMPUTATION ON THE NERVOUS SYSTEM.

Vanlair (Bul. Acad. Med. Belgique, v. 9,) states that after section of a nerve or amputation, whether there is or is not regeneration, there is always a proliferation of fine fibres in the central nerve stump. The changes in the roots and cord are inconstant. In the latter the degeneratian is chiefly in the gray matter especially of the ventral cornua. The changes in the cord are more considerable the longer the interval since the injury and the younger the subject. The alteration is conditioned by the disease more than the operation.

WALLER'S LAW.

The law formulated by Waller, that the trophic centres for the sensory root of a spinal nerve lies in the spinal ganglion, while that of the ventral root is in the cord (probably the multipolar cells of the anterior cornu) has at various times been investigated with results by no means accordant. VEJAS.[1] states that if both roots are torn away the central

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[1] Ein Beitrag zur Anatomie und Physiologie der Spinalganglien, Munich, 1883

stumps disappear and the sensory root attached to the ganglion also disappears. Moreover the ganglion itself degenerates on section of the peripheral nerves. JOSEPH[1] found that Waller's law holds good for the section of the motor root, but that when the dorsal root is cut some fibres degenerate in the ganglion and peripheral nerve, and after section of the peripheral nerve a partial degeneration of the ganglion and root follows. KAHLER[2] investigated the subject with care and found Waller's law to be sustained.

SINGER AND MUENZER[3] reinvestigated this matter by means of Marchi's method and, aside from traumatic degeneration and normal atrophy, find that Waller's law prevails without exception. These results agree with those of Krause and Friedländer.[4]

It seems to the writer that the divergence between the authors quoted may be explained in part at least by the fact that Singer and Münzer operated upon the sciatic roots, while the other investigators used the cervical. It is certain that the course of the fibres is much more complex in the cervical ganglia and roots and the simple scheme expressed by Waller's law, is interfered with in various ways, It has been shown that in this region the course of the motor fibres is not constantly in the ventral root. It is not proven that there may not be great variation in different individuals of the same species.

CIRCULATORY CHANGES IN EPILEPSY.

BECHTEREW has succeeded in observing through a pane of glass set in a dog's skull, the hyperaemia accompanying an epileptic attack induced by faradizing the cortex or injecting cinchonin into the circulation. (*Neurol. Centralblatt*, 1891, 22.)

TRAUMATIC INJURIES TO THE BRAIN.

1. Coal miner. Injury due to falling stone. Depressed fracture of parietal. Aphasia, deviation of mouth and tongue to the right, motor powers of right arm and leg impaired. Operated by trephining. Inner table found more extensively fractured. Prompt recovery. *Lancet*, Feb. 13, 1892.

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[1] Archiv. f. Anat. u. Phys. 1887.

[2] Prager Med. Wochensch., 1885.

[3] Beitraege zur Anatomie des Centralnervensystems, insbesonderes des Ruckenmarkes. Denkschriften der Kais. Akad. d. Wissenschaften, LVII. p. 569.

[4] Arch. f. Anat. u. Phys. 1887.

2. Laborer. Struck by iron column above right ear and thrown upon his head. Bleeding from ears, eyes and mouth, paralysis of both sides of face and fauces, bilateral lagophthalmus, convergent squint and enlarged pupil of left eye, headache. Expectant treatment, gradual recovery. *Medical News*, March 5, 1892.

3. Bullet entered at back of hard pallet near middle line at left, passed through the base of brain cephalad of optic chiasm and mesad of left optic nerve, traversing first frontal convolution, emerging from its upper part. Fragments removed, drainage and iodoform dressing. Suppuration behind left eye which subsequently discharged through wound. Recovery with partial deafness of left ear, due to fractures at base of skull. *Brit. Med. Journal*, March, 1892.

4. Boatman, 24 years old. Bruise wound 8 cm. above left ear, 2 cm. in diameter. Unconscious, contraction of right pupil, strasbismus, right arm more rigid. Trephined, removed extensive epidural clot. Paresis of arm removed. Recovery.

5. Intoxicated man by a fall ruptured anterior branch of middle meningeal artery. No external signs. Trephined, clots removed. Symptoms—motor aphasia and diminished sensation on right side, some indication of facial paralysis—disappeared on removal of clot.

6. Man injured by fall. Headache three weeks, then unconscious, vomiting, general convulsion. Double optic neuritis, and right hemianopsia. Trephined, abcess in left angular gyrus, removal of 2 ounces of pus. After operation word-blindness. Death. *Lancet*, Nov., 1891.

7. Compound fracture with extensive comminution of right parietal at the centre of the region of Rolando. Left arm paralyzed below elbow, sensation and intelligence unimpaired. Operation revealed extensive splintering of inner table. Subsequent loss of brain substance by hernia cerebri. Partial recovery. *New York Med. Journal*, Jan., 1892.

PATHOLOGY OF THE SOLAR PLEXUS.

It has been known for some time[1] that glucose, acetic acid, and albumen are formed in the urine of animals in cases of injury to the solar plexus. DR. CRISTIANI (*Riforma Med.*, Sept. 1891,) has studied a "vaso-paralytic diarrhoea," which is common in insane hospitals and finds it occasioned by degeneration of the plexus. Chemical examination discovered glucose and albumen but no acetic acid in all the cases examined.

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[1] LUSTIG, Sull' acetonuria sperimentale, Lo Sperimentale, XLV, 5-6.

THE AUDITORY CENTRE.

C. K. MILLS (in Brain LVI,) concludes, as a result of clinical testimony, that the centre for word-hearing is situated in the caudal third of the first and second temporal convolutions, its exact position being in line with or just cephalad of the caudal extremity of the horizontal branch of the fissure of Sylvius.

SOUL BLINDNESS IN THE DOG.

RICHET (see literature) reports a case of experimental psychical blindness in which the autopsy showed bilateral injury to the gyrus ectosylvianus and a small part of the gyrus sylvianus, which accordingly are considered the psychical visual centre.

FUNCTIONS OF GANGLION CELLS OF THE CERVICAL CORD.[1]

After an historical and topographical introduction the author discusses the histological and histochemical reactions of the of the various kinds of cells in the cervical region of the foetal and adult man, gorillà, hedgehog, mole, shrew, bat, and rabbit. The cord was hardened in Müller's fluid and cut in serial sections of 20 micros thickness and then stained with naphtylamin brown. The cells of the various regions were counted and grouped in accordance with their size and color preference. Thus the author recognizes chromophilous cells which stain deeply and chromophobic cells which resist the stain. He concludes that the more completely the cell is subordinated to the influence of the brain, the more highly chromophile it is. The chromophobic cells are more independent. The energy and complexity of the motion of the muscles controlled varies with the number and size of the cells of the region. The niduli of the dorsal muscles extend throughout the entire length of the spinal cord in the median column. The accessory nidulus lies laterad of this from the medulla to the sixth or seventh segment. The phrenic nidulus is in the third to fifth or sixth segments between the above, but phrenic fibres also arise from the mesal dorsal groups. The brachial nidulus lies in the lateral portion and begins in the third or fourth segment and extends into the first or second dorsal segment. The cephalic portion is broken up into several groups, supplying the muscles of the shoulder girdle and flexors and extensors of the fore arm; the caudal part is di-

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[1] O. KAISER, Die Functionen der Ganglionzellen des Halsmarkes. The Haag, 1891.

vided into ventral cells of the adductors of the upper arm and the triceps and dorsal cells supplying the flexors and extensors of the fingers, etc.

THE PONS AND ANARTHRIA.

S. MARKOWSKI,[1] concludes from the results of an autopsy that (1.) unilateral softening of the left pons does not necessarily produce disturbances of speech even when the entire so-called pyramidal tract is destroyed. (2.) If the left pyramidal tract is injured then a spot of softening affecting the meso-dorsal part of right pyramidal tract is sufficient to produce anarthria. (3.) The motor speech tracts are double in the pons. (4.) In the pons the motor speech tract lies in the dorso-mesal part of the pons and is accompanied by the tract for deglutition.

ELECTRICAL VARIATION IN THE CORTEX.[2]

By connecting two regions with two like galvanometers the change of potential due to disturbances of various sorts were observed. A lessening of potential was found in the middle and lower part of the convolution behind the crucial sulcus when the anterior extremities are irritated. In the monkey the same region lies behind the sulcus sigmoideus where the sulcus angularis begins. The sensory centre for the hind limb lies near the mesal surface in the monkey and in the dog in front of the crucial sulcus. Touching the face with the finger produces a lowering of potential in the gyrus lying below the sulcus sigmoideus and in front of the anterior brachium of the sulcus angularis. Illumination of the eye caused such changes in the visual sphere of Munk, while in monkeys it was only observed in the upper part of the gyrus angularis.

The change in potential was greater when the stimulus had what may be called a normal intensity. The changes are supposed to be due to simple psychical processes (sensations and perhaps concepts.)

LUCIANI'S STUDIES OF THE CEREBELLUM.

An abridgement of this great work has been published by Pescarolo in *Archiv. Ital. de Biologie*, XVI, 2–3.

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[1] Zur Casuistik der Herderkrankungen der Brucke mit besonderer Berucksichtigung der durch dieselben verusachten anarthrischen sprachstoerungen. Arch. f. Psychiatrie, 2.

[2] BECK and CYBULSKI Further investigations on the electrical phenomena in the cortex of apes and dogs. Sitzungsberichten der Akad. der Wissensch. in Krakau, 1891.

Median division of the cerebellum into two halves produces enfeeblement of all voluntary motions and diminution of muscular tone. Astasia, or the various trembling irregular and uncertain modifications of voluntary motion, is pronounced and these symptoms are never fully removed. Schiff's and Vulpian's statements that symmetrical lesions have no effect, prove false. The worm was successfully extirpated in four dogs and two monkeys. The atonia, astasia and paresis were most marked in the posterior extremity. One complete half of the cerebellum was successfully removed in four dogs and three monkeys. The effect of the irritation consisted in rotation about the longitudinal axis (toward the uninjured side) deviation of the eye and nystagmus toward the uninjured side, Curvature of the spinal column toward the operated side and tonic cramp motions of the fore foot (sometimes also hind foot) of the operated side. Paresis, Atonia and Astasia were present, especially on the operated side. Compensation occurred by learning to modify the opposing muscles not by a substitution of function in brain regions. Trophic disturbances occasionally appeared.

A nearly complete extirpation of the cerebellum of a dog which lived two years and a half thereafter, is recorded. The irritative processes lasted ten days and consisted in motor excitement ond tonic cramps of the cervical, dorsal and anterior extremity muscles, clonic motions of posterior extremities and convergence of the eyes.

Locomotion was not acquired for more than a year, during which time walking and standing (but not swimming) were impossible. A certain amount of ataxia remained permanently. Intelligence, sensation and sexual functions were undisturbed. The asthenia is explained by the supposition that a part of the motor impulse passes through collateral tracts via the cerebellum. The astasia is explained as a result of imperfect summation of motor impulses; this uncertainty or trembling disappears when the motion is more rapid. Great emphasis is laid on the fact that the cerebellum acts as a whole. The functions of the cerebellum therefore are, (1) intensifying the potential energy of voluntary motion, (2) enhancing the resting tone of muscles, (3) it accelerates the rhythm of motor discharge and fuses into continual discharge. The conclusions of this author are such as find strong confirmation in the histological studies of the writer, who has shown the connection between pes pedunculi and cerebellum more complete than heretofore supposed.

In the case of four dogs, one or both sigmoid gyri were extirpated in connection with the cerebellum, and Luciani concludes that the compensatory movements by means of which the animal, whose cerebellum has been removed, becomes capable of maintaining its equilibrium in the erect posture, etc., depend on sensori-motor areas of the cerebrum.

The elaborate review of this work at the hands of Seppilli, which appears in the July number of the *Alienist and Neurologist*, may be recommended with the reservation that the distinguished reviewer has been unable to divest himself of a national pride and personal feeling for his friend, which praiseworthy feelings have led him to do scant justice to those whose views are extended and particularized by the elaborate work cited.

In striking contrast to this work is a paper by Tolet,[1] which is (almost unintelligibly) translated in the *Alienist and Neurologist* for April. The curious mixture of false analogy and indiscriminating employment of pathological data has a savor of antique chiromancy. The cerebellum proves accordingly to be the seat of the affections. Specimens of the translations run thus: "All mammals near the water have the cerebellum well developed." "The author understands the protuberance in the nervous system of the brains." "The cerebrum is the anterior portion of the backbone having the motive faculties." This is worse than the translation of "Hirnrinde" by *Dura mater*, which occurs in Hoeffding's psychology. The scholarly and careful editor is not often thus imposed on and a recollection of sundry typographical errors in our own pages of late predisposes to silence.

A suggestive paper on Tumor of the Cerebellum in *The Alienist and Neurologist* for April, 1892, suggests the possibility of successful operative interference in these distressing cases.

THE DEVELOPMENT OF THE BRAIN OF FISHES.[2]

The portion of this well-illustrated memoir which relates to the brain is brief and chiefly devoted to the external characters and changes in form. The anterior enlarged portion of the neurochord extends the whole depth of the free-region of the embryo, forming a somewhat rhomboidal mass, rounded above, deeply carinate below. The growth of the

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[1] Neurolog. Centralblatt, 1891.

[2] McINTOSH AND PRINCE. On the Development and Life-histories of the Teleostean, Food and other Fishes. Trans. Roy. Soc. Edinburg, Vol. XXXV, Part III, No. 19, 1890.

large optic vesicles, as two massive ellipsoidal bodies protruding laterally from this region is an early and notable feature. The part which becomes the mid-brain is very early distinguished by its greater breadth and volume. No transverse cerebral folds appear until about four-fifths of the yolk are enveloped. An anterior portion—united mid- and fore-brain—can now be distinguished from the hind-brain.

The first indication of a true neural canal appears as a fine cleft separating the median cells of the encephalon along a vertical longitudinal plane. At an early stage the brain becomes divided into two flat, thick plates of cells placed vertically between the eyes (Ryder.) At its anterior termination the canal sends off two lateral vertical continuations, forming a cruciform fissure which marks off the fore-brain.

The flexures are described in some detail. A remarkable passage is the following:

"A small median swelling, not unlike the hypophysis in structure, lies in front of the latter—that is, behind and slightly under the point where the optic nerves decussate. When further advanced such appears to form the hypoaria or lobi inferiores—so well developed in Percoids, and their special ventricles in the adult communicate with the lumen of the infundibulum."

If we understand the passage correctly the authors have certainly wrongly identified the hypoaria anlag. It is probable that the saccus vasculosus and the hypophysis proper have been observed. Histological and histogenetic observations unfortunately are wanting.

THE DIENCEPHALON OF SELACHII AND AMPHIBIA.[1]

Instead of the notice prepared we insert an auto-abstract from the Anatomischer Anzeiger, VII, 15, which will present the points considered most important by the author in his own words.

The brain of selachians was investigated by means of 25 series of sections from various rays and sharks. Especial advantage accrued from the use of series from various stages of development which made it possible to determine with considerable accuracy the sequence of axis-cylinder development in different tracts. The diencephalon of various species were first described and this was followed by a comprehensive illustrated

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[1] L. EDINGER. Untersuchungen ueber die Vergleichende Anatomie des Gehirns: 2. Das Zwischenhirn, Part I. Das Zwischenhirn der Selachier und der Amphibien. Abhandlungen der Senckenberg'schen naturf. Gesellschaft

summary of the diencephalon of Selachii in general. It is advantageous to distinguish a frontal from a caudal segment of the diencephalon. The former is the direct continuation of the basal and lateral portions of the prosencephalon, and is chiefly formed laterally by the pedunculi cerebri and dorsally by the plexus choroideus. At the caudal level the ganglia habenulæ, which are composed of two different portions, are seated on the pedunculi of either side. The two habenulæ differ considerably in size. The caudal portion is called the pars infundibularis. It begins behind the chiasm and contains in addition to the previously described lobi laterales, a lobus posterior. Ventrad of the latter is formed the wall of the saccus vasculosus. The structure of these parts is minutely described.

The following tracts are indicated: 1. The basal prosencephalic tract, of which the portion which first becomes medullated passes to the infundibulum, the other passes farther caudad. 2. The mantle tract from the mantle of the prosencephalon, which passes ventrad ectad of the optic fibres and decussates caudad of the chiasm. This decussation corresponds with what has hitherto been known as the commissure transversa Halleri. After decussating the fibres pass obliquely dorsad over the diencephalon and sink into the basal portion of the roof of the mesencephalon, beyond which they could not be traced. The mantle bundle is the last of the tracts of pros- and diencephalon to become medullated. Dorsad of it the thick fibres of the decussatio transversa descend from the caudal part of the mesencephalon. These cross caudad and dorsad of the chiasm.

[The author elsewhere admits that the mantle bundle may not arise in the parts truly homologous of the mantle of other vertebrates.] The caudal portion of the ganglia habenulæ are united by the decussatio thalami dorsalis. [Commissura habenulæ, Herrick.] From it ectad the tractus descendens ganglii habenulæ may be traced downward along the diencephalon. Other tracts pass to the prosencephalon and roof of the mesencephalon. The fasciculus retroflexus (Meynert's bundle) passes from the frontal portion of the ganglion to apparently unite with its fellow in the interpeduncular. In anticipation of subsequent investigation with better methods the scattered cell masses of the infundibulum were not resolved into ganglia. It is only possible to locate with certainty a corpus geniculatum beneath the optic fibres on the ectal aspects of the diencephalon. In any case it is necessary to distinguish a central grey of variable thickness [ventricular cinera] from the true grey matter of the diencephalon. Two tracts arise from it, the ventral decussation of the central grey and the tractus ad decussationem infundibuli, the latter ending after decussation in the wall of the saccus vasculosus.

The real origin of most of the diencephalic tracts is the dorso-caudal region of the pars infundibularis. Thence springs the fasciculus longitudinalis, which can be followed with a clearness hitherto unattained from its origin to the ventral column of the cord. Laterad and caudad of it arises the processus ad cerebellum, which, after passing a short distance on the basis pass into the decussation of the cerebellar peduncles and thence to the cerebellum.

The diencephalon of amphibians was also studied by various methods and in numerous species. Careful studies of the infundibular region especially were made. The author finds the following connections with the prosencephalon: (1) the basal prosencephalic bundle, as in Selachii; (2) tract to habenulæ; (3) diencephalic root of the olfactory; (4) doubtfully, a decusatio post-optica behind the chiasm corresponding to the mantle bundle of Selachii. From the grey matter of the diencephalon arise tracti thalami anterior and posterior from the two ganglia of that region. The connections of the habenulæ are as in Selachii.

The paper deserves careful study. Respecting the mantle bundle and the ventral commissures of the diencephalon the results seem to be unharmonizable with those of the present writer derived from a detailed study of the teleosts and amphibia. The basal prosencephalic bundle contains the present writer's fornix tract. The figures are diagramatic, but very useful. The remaining installments will be awaited with interest.

THE NERVOUS SYSTEM OF PSEUDOSCORPIONS.[1]

The central nervous system, which lies in the cephalic part of the cephalothorax, consists, as in all Arachnida, of a supraœsophagal ganglionic mass which is so closely connected with the thoracic ganglia that lateral commissures are practically absent. The two lobes together constitute an oval mass about .5 mm. long and .4 mm. in greatest width. Of

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[1] H. CRONEBERG. Beitrag zur Kenntniss des Baues der Pseudoscorpion. Bul. Soc. imp. des Naturalistes de Moscow, 1888, 3.

this the supraœsophagal ganglion forms about one half and rises above the cephalic part of the thoracic ganglion as a strongly prominent dorsally flattened elevation of nearly circular outline which cephalad, where it almost adjoins the pharynx, falls off abruptly to the œsophagus. The lower thoracic ganglion forms likewise a rather thick mass and is expanded posteriorly and assumes a somewhat radial form by reason of the nerves issuing from it.

The whole ganglionic mass is clothed with fine neurolemma upon which there occasionally appear elongated nuclei and which extends out upon the nerves. Beneath the neurolemma is a closely packed layer of nerve cells which have vague contours and roundish, deeply staining nuclei of .006 mm. diameter; these cells surround the central mass on all sides, but are thinnest on the dorsal surface of the thoracic ganglion. Nerve cells of greater dimensions were not observed in *Chernes* and nothing can be said respecting their processes. This layer is thickest on the surface of the supra-œsophagal ganglion as well as on the ventral surface of the thoracic ganglion.

The central mass in the region of the thoracic ganglion is divided into 6 pairs of elongated granulo-fibrous accumulations from which spring the nerves to the five larger extremities and the sixth posterior nerve pair and which are surrounded by a connective sheath which seems to originate from the connective tissue about the œsophagus. . . . In longitudinal sections there appears in the fore-part of the supraœsophagal ganglion a protuberance of the inner substance of both sides perhaps forming the ganglion of the mandiblary palp. . . . No rostral ganglion, such as found by Schimkewitsch in Aranea, was found in *Chernes*.

Two strong bifurcating nerves spring from the supraœsophagal ganglia which can be followed to the vicinity of the mandiblary palp and probably innervate them. Between these an azygous nerve arises and passes over the pharynx. . . . At a higher level two small nerves spring from the cephalic part of the brain and are regarded as atrophied optic nerves, although eyes are absent in *Chernes*. Two very large maxillary nerves arise from the thoracic ganglia and give off a fine mesal branch which at once subdivides. The nerves of the extremities follow and finally, at a higher level, a strong pair which divides to send the mesal branch to the genitalia and the lateral to the liver sac,"

THE DEVELOPMENT OF THE VENTRAL GANGLIONIC CHAIN OF INSECTS.

The most important paper which has appeared for years on the nervous system of arthropods is that of VEIT GRABER.[1] It is purely morphological and embryological, lacking the histology in the strict sense, but is well illustrated and affords a number of new facts which we hope to refer to in a fuller comparative notice hereafter.

THE ORIGIN OF THE NERVOUS SYSTEM IN POLYZOA.

DAVENPORT[2] agrees with Hatschek's (as contrasted to Harmer's) views that the brain is an invagination of the floor of the atrium. "The nerve fibres are very evident in the adult ganglion of *Cristatella*, and in addition to them, there is a cavity, ontogenetically derived from the atrium which contains no histological elements."

The lophophoric nerves, passing down the middle of each lophophore arm, are formed as outgrowths of the ganglion. The proximal part of the lophophoric nerve is to be regarded as a pocket of the brain. "The peripheral nervous system in *Phylactolæmata* arises from the brain as an outgrowth of its walls."

ON THE INNERVATION OF THE CERATA OF SOME NUDIBRANCHIATA.[3]

The cerata—dorso-lateral processes of the body wall—of the Nudbranchs are innervated in various ways. In Polycera and Ancula they are innervated entirely by the pleural ganglia; in Dendronotus the pleural ganglia are assisted by a few fibres from the pedal; in Tergipes they are innervated entirely by the pedal ganglia; in Facelina the pedal ganglia are assisted by a few fibres from the pleural. Herdmann thinks the evidence at hand is sufficient to prove that in this case the nerve-supply cannot be taken as a sure indication of homology. He also makes the following suggestion:

"(1). These ceratal outgrowths may be truly epipodial, homologous with the epipodia of *Trochus*, starting at first as pedal structures supplied with nerves from the pedal ganglia; and (2) may have secondarily acquired, possibly as the result of changes in form, position, and relations

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1. Studien am Keimstreif der Insecten, Denkschriften der Kais. Akad. der Wissenschaften zu Wien., LVII, 1890.

2. Bul. Mus. Comp. Zool., XX, 4.

3. HERDMANN, W. A. and J. A. CHUBB. Quart. Jour. Micro. Sci., Vol XXXIII, pp. 541-558; pl. XXXII-XXXIV.

to other organs, a supplementary nerve-supply from the adjacent integumentary nerves arising from the pleural ganglia; and (3) this supplementary supply, while remaining subordinate in *Facelina*, may in other forms have gradually come to supplant the original epipodal (pedal) nerves, which (on this view) have now completely disappeared in such forms as *Polycera* and *Ancula*, and are only represented in *Dendronotus* by the pleuro-pedal anastomosis. This is however only a suggestion which we do not feel able to support or press further at present."—[C. H. T.]

NERVOUS SYSTEM OF PENTASTOMUM TERETINSCULUM.

In his late paper on the Anatomy of Pentostomum teretinsculum[1] Mr. W. BALDWIN SPENCER devotes a few pages to the nervous system. The following is a brief summary of those pages:

There is a large double subœsophagal ganglion, which gives origin to nine pairs of nerves; but this is no supraœsophagal ganglion. However a commissural ring extends from the subœsophagal ganglion around the œsophagus. In this subœsophagal nerve-mass the whole of the ventral chain is concentrated; and from it nerves pass to all parts of the body. Histologically this nerve mass consists of an inner cord of fibres surrounded by a shell of nerve cells. These cells are more numerous at the origin of the nerves than elsewhere. As a rule the cells are pear-shaped and give origin to but one fibre; but in rare cases two or even three processes arise from the same cell. At the origin of the nerves and all along the posterior cords may be seen thin elongated cells which have been pulled out in the direction of the branch.

Sense Organs.—In the female there are present eight, and in the male nine pair of sensory papillæ. Two are much more prominent than the others and have been called by Leuckart, "Tastpapillen." The tastpapillen and a few other papillæ undoubtedly contain end-organs. It is not certain what the function of these papillæ is. Probably they function as tactile organs, keeping the parasite informed as to the condition of the blood supply in its host.—[C. H. T.]

PRIMITIVE SEGMENTATION OF THE VERTEBRATE BRAIN.[2]

Mr. Waters thinks that the fore-brain is composed of at least two well-marked neuromeres, from the first of which the olfactory nerve arises

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[1] Quart. Jour. Micro. Sci., Vol. XXXIV, part I.

[2] WATERS, BERTRAM H. Quat. Jour. Micro. Sci., Vol. XXXIII, p. 457-476; pl. XXVIII

The mid-brain is composed of two neuromeres, from which the third and fourth nerves originate. The hind-brain consists of six neuromeres. Except as regards the origin of the sixth nerve and corresponding neuromere, Waters thinks that the views of McClure and Miss Platt are correct. When the abducens neuromere exists, the sixth nerve occupies the theoretical position ; but when fusion has taken place between the trigeminus and abducens neuromere, the sixth nerve is shifted caudad towards the seventh and eighth nerves.

In all probability, the central nervous system of the primitive vertebrate consisted of a series of symmetrical intersomitic segments. The segments of the head and trunk regions were perfectly homologous in origin, character, and function. Therefore the complex encephalon has been evolved by a direct differentiation and specialization of the ten or eleven segments of the primitive neuron (neuraxis). The great differentiation and rapid ontogenetic increase of the anterior brain region seem to account for the relatively greater size and the early degeneration of the segments of the fore-brain and mid-brain, and for the persistence of the segments of the more primitive hind-brain.—[C. H. T.]

THE ANNUAL OF THE UNIVERSAL MEDICAL SCIENCES.[1]

This yearly report of the progress of the general sanitary sciences throughout the world forms five substantially and even elegantly gotten up volumes illustrated with chromo-lithographs and numerous cuts.

Volume II contains Diseases of the brain, by LANDON C. GRAY, M. D. and DRS. PRITCHARD and SCHULTZ ; Diseases of the spinal cord, by W. R. BIRDSALL, M. D.; Peripheral nervous diseases, by P. C. KNAPP, M. D.; Mental diseases, by C. H. ROHE, M. D., and other matter of in-interest to the neurologist.

In volume III is a valuable discussion of Surgery of the brain and nerves, by J. W. PACKARD, M. D.

The departments of Opthalmology and Otology, the first by DR. OLIVER, and the second by DRS. TURNBULL and BLISS, will be found in volume IV, as also the section on Histology, which is relatively neglected.

The section on Physiology is by Professor W. H. HOWELL, and it is needless to say is excellently done. Indices and other addenda add to

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[1] Edited by CHARLES E. SAJOUS, M. D. and seventy associate editors. F. A. Davis, Phila.

the usefulness of a work which deserves abundant patronage. We would venture to suggest that the list of journals could be arranged either alphabetically, topographically or by subjects, and the addition of the name of the editor or publisher would be a genuine service.

THE TEMPERATURE SENSE.[1]

This paper is the most elaborate and detailed discussion of temperature sensation yet written. It is introduced by a full historical review and analysis in which several new terms are proposed; for example, Haptics (Haptik) is proposed as correlated with optics and acoustics to include the contact sense and "pselaphesia," (the latter containing both tactile and muscular sense.) Pselophesia is the active, contact sense the passive aspect of Haptics.

It would be easy to select topics for discussion without doing violence to the (rather slight) unity of the paper, but a synopsis is impossible. He says we are forced to consider the external world as given in consciousness while we subsequently reach the correlated idea of an inner self distinct from it. Subjectivity is what is to be explained. A more reasonable view seems to us to be that the two are inseparable counterparts, experience beginning with no distinct element of either. The sensation is certainly prior to any external reference of it and the external reference involves an implicit recognition of self. Dessoir says, "Organic influences at the periphery are causes of the chief variations in attention. The special causes to be determined in each case." The subject of apperception is discussed. In general the psychological analysis is in some respects unique.

Respecting the temperature sense the following summary must suffice.

The temperature sense is a simple modality of perception belonging to the group of summation sensations and possesses two qualities which vary from a common zero. There is no evidence of two modalities or two sets of end-organs. Blix's points are artificial products. Whether we feel heat or cold does not depend on what point is irritated, but what kind of a stimulus operates on a given point.

It is conceived that in sensations of cold the warmth of the skin is reduced and as a result the nervous end apparatus expands and thus pro-

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[1] DESSOIR, MAX. Ueber den Hautsinn. Archiv. f. Anat. u. Phys., 1894, 3 and 4.

duces a perfectly distinct variety of irritation through the medium of an indifferent nerve upon the cerebrum.

The intensity of a temperature sensation does not correspond directly with the kinetic energy of the motion but on five other factors; 1, the size of the surface, 2, period of irritation, 3, thickness, 4, conductivity, and 5, temperature of the skin. Pathological data show that the temperature sense is to a certain extent independent of the other senses, being nearest related to pain. Irritation of a moderately sensitive skin with —10° C exhibits an interval of two-tenths of a second between pressure and temperature sensation, with a temperature of + 40° C, six-tenths second. There is no evidence of a specific energy of the temperature nerves.

PROFESSIONAL MORALITY.[1]

Contrary to our usual custom, we call attention to a work not directly in line of this Journal, because a perusal of this interesting and well written volume reveals the fact that those professional maxims which the experience of generations of medical practitioners has proven most essential to success, are wonderfully like the universal canons of morality and the dicta of practical experience in all professions. No one, whether a member of a profession or not, can fail to profit by the perusal of a book equally simple and sagacious. It is very satisfactory to read the uncompromising rebuke to the (too numerous) class of physicians who recommend illegitimate sexual intercourse as a remedy for a variety of diseases and it may be hoped that society may not neglect to provide the sanctions necessary to make it effectual.

MATERIALISM AND MODERN PHYSIOLOGY OF THE NERVOUS SYSTEM.[2]

This little book was examined with much interest. It is largely devoted to a vigorous exposition of the inconsistencies of the positions of Professors Huxley and Romanes, particularly in claiming to recognize the independent existence of consciousness and thus avoiding materialism, while, as the author claims, soon returning to it as the only scientific position possible. We are unable to see that our author assists us out of

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[1] D. W. CATHELL, M. D. Book on the Physician Himself, and Things that Concern his Reputation and Success. Tenth Edition (Author's Last Revision). Royal Octavo, 348 pages. Price, post-paid, $2.00, net. Philadelphia: The F. A. Davis & Co. Publishers, 1231 Filbert Street.

[2] WILLIAM H. THOMPSON. G. P. Putnam's Sons, New York, 1892.

the undoubted dilemma by such a statement as this (p. 41.) "Instead of consciousness or thought being a function of nervous tissue, the perception of a sensation through nervous tissue is a function of consciousness—that is to say, consciousness is independent of nervous tissue, and uses nervous tissue to perceive with." We regret to say that the comparative anatomy introduced is not faultless, as where the author states (p. 60) that the carp does not smell at all and has no olfactory bulbs. The figures are deplorably inaccurate and crude. Respecting the physiology of the brain, we are told that it is plain that the consciousness can use one or the other of the hemispheres of the brain or both together by means of the three commissures or bridges between them, as it uses one or both eyes by means of the optic commissure." The modern form of monism as formulated by Fechner and Morgan, is not referred to. It is to be feared that there are many years of dreary theorizing and weary investigation between us and a solution of the problem so vigorously attacked by the author.

ORIGIN AND DEVELOPMENT OF THE CENTRAL NERVOUS SYSTEM IN LIMAX MAXIMUS.[1]

The slugs were kept in tin vessels and fed on cabbage, on which the eggs were deposited. These were removed to a watch glass of water and placed in a moist chamber. The eggs were killed in chromic acid 0.33 per cent., or Perenyi's fluid. In the former, after removing the membrane and albumen, they were left an hour or two, in the latter only two to three minutes. Picrocarminate of lithium and Czoker's cochineal were used as stains and the material quickly imbedded in paraffin. The nervous system makes its appearance on the sixth or seventh day after the egg is laid. The central system consists of four pairs of ganglia, cerebral, pedal, pleural, and visceral, together with one abdominal ganglion. To these are added a pair of buccal and one mantle or olfactory ganglion. The ganglia arise separately. The components of three of the five pairs are joined together later by commissures. Secondarily-produced connectives also serve to join the cerebral ganglia to the pedal, the pleural, and the buccal; the pleural to the pedal and visceral; and the visceral to the abdominal. The growth of the ganglia is rapid; they are well formed and in their ultimate positions by the sixteenth day. All the ganglia,

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[1] ANNIE P. HENCHMAN. Bulletin of the Museum of Comparative Zoology, XX, 7.

with the possible exception of the pleural, are derived from the ectoderm—the cerebral in part by invagination, the others exclusively by cell-proliferation without invagination. The pedal ganglia are joined by two distinct commissures, the anterior one being earlier. The buccal ganglia make their appearance at about the same time as the pleural, and undergo no change of position.

BOOKS RECEIVED.

HOPKINS, L. P. Educational Psychology, a treatise for parents and educators. *Lee and Shepard*, Boston ; 50 cents.

The attempt is made to compress into the space of 96 small pages the essentials of psychology. On the whole, this impossible task is as well done as could be expected. A number of pages are devoted to the structure of the brain and these contain fewer errors than is usual in books of this class.

The cerebellum is described as similar in structure to the cerebrum and as "incessantly distributing through all its fibrous connections a continuous current of electric force through the nervous system, showing itself in every conscious or unconscious nervous act."

A more serious fault is a certain vagueness of expression which occasionally appears in the subjective sections, but the volume will no doubt serve a good purpose in awakening interest in the subject.

BERGEN, J. Y. and BERGEN, FANNY D. A Primer of Darwinism. *Lee and Shepard*, Boston; $1.25.

Well printed, usefully illustrated and well adapted to its purpose, containing citations sufficient to indicate the sources.

DOLBEER, A. E. Matter, Ether and Motion. *Lee and Shepard*, Boston; $1.75.

A popular discussion of physical problems. It is an instructive index of modern tendencies that *life* is given a place among the chapters. He says "there is little reason to doubt that, when they [the chemists] shall be able to form the substance protoplasm, it will possess all the properties it is now known to have, including life; and one ought not to be surprised at its announcement any day." This will be news to the physiologists and physiological chemists who find even a proximate "bausch analysis" as unsatisfactory to-day as ever. Bütschli's recent experimental imitation of protoplasm can hardly be said to help us much.

CAMPAYRE, G. Translated by PAYNE, W. H. The Elements of Psychology. *Lee and Shepard*, Boston; $1.00.

This volume is mechanically well adapted to the use of students. It is needless to say that it treats the subject from the subjective standpoint and quite conservatively. The use of such terms as "the faculties" seems unfortunate inasmuch as the discussion is much more adequate than this terminology leads one to expect.

The author recognizes the limitations and the student is not misled by dogmatic definitions of consciousness, memory and the like. The technical and historical index which is appended would be more useful if made more accurate and extended. "*Cerebral circumvolutions*" are defined as "the sinuous furrows presented by the upper surface of the brain." "*Cells.* A term in natural history, denoting anatomical elements which unite with fibres to form tissues."

The calm and judicial tone of the book and the very conservatism, which might be regarded a defect in a general work, added to the clearness of thought and style, recommend it to pedagogists.

CHENEY, S. P. Wood Notes Wild. *Lee and Shepard*, Boston, 1892; $2.00.
(See editorial.)

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(See elsewhere in this number.)

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This well printed volume contains Chas. L. Dana's paper on Scleroses of the spinal cord and S. Weir Mitchell's interesting address on the early history of instrumental precision in medicine, which is overflowing with interest to the non-medical as well as the professional man.

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LITERARY NOTICES.

Interrelations between Plants and Insects.[1]

Few recent additions to the subject of instinct are more significant than the contribution above referred to. The remarkable habit of the yucca moth of carefully cross-fertilizing a plant, in order that the egg which it deposits in the ovary of the plant may find suitable conditions, seems at first as difficult to explain by an appeal to instinct developed under natural selection, as it is incredible when considered the result of analytic intelligence. The flowers of the yucca are produced in large panicles and are characterized by the anthers not reaching anywhere near the stigma, so that self-fertilization could take place only by the merest accident. The stigmatic opening is at the tip of the prolonged style and is nowhere within reach of the stamens, while the pollen either remains attached to the withered anthers or falls in lumps to the bottom of the perianth. It cannot be introduced into the stigmatic tube without artificial aid and the plant depends absolutely on the little white moth known as *Pronuba*.

While the male of this moth resembles others of the family (*Tineina*) the female has remarkable structural peculiarities, which admirably adapt her for the functions she has to perform, for she must fertilize the plant, since her larvæ feed upon its seeds. A pair of maxillary tentacles which are prehensile and spinous on their under surface are peculiar to the genus *Pronuba* and exist in no other genus of the over 24000 described Lepidoptera. A long and peculiarly modified ovipositor, resembling that of certain Hymenoptera, is another peculiarity. It is by means of the latter with its saw-like appendage that the eggs are inserted within the ovary of the yucca.

As preliminary to this process the female collects a load of pollen, during which process the maxillary palpi are used in scraping the pollen

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[1] Riley, C. V. Some Interrelations of Plants and Insects. Proc. Biol. Soc. of Washington. Vol. VII, May 28, 1892.

together. Subsequently the pollen is kneeded into a large mass and is then deposited on the stigma of the ovary in which the egg is laid. This is the more remarkable since the stigma is devoid of nectar and there seems to be no inducement assignable for this laborious fertilization, except the distant and altruistic one of providing food for the generation to come. The miser does not provide for his grandchildren more instinctively than does the yucca moth for her progeny.

It is curious to observe that a moth closely resembling the *Pronuba*, but without its value to the plant is almost invariably associated. (We regret that American entomology should see fit to perpetuate the word "Bogus" instead of spurious in this connection.)

"Now, when it comes to the bearing which the history of these little moths has upon some of the larger questions that are now concerning naturalists (for instance, the transmission of acquired characters, or the origin, .davélopment, and nature of the intelligence displayed by the lower animals), broad fields of interesting opinion and conclusion open up before us—fields that cannot possibly be explored without trenching too much upon your time. I will close, therefore, with a few summary expressions of individual opinion, without attempting to elaborate the reasons in detail, and with the object of eliciting further discussion, which is one of the objects of the paper. My first conviction is that insect life and development give no countenance to the Weissmann school, which denies the transmission of functionally acquired characters, but that, on the contrary, they furnish the strongest refutation of the views urged by Weissman and his followers. The little moths of which I have been speaking, and indeed the great majority of insects—all, in fact, except the truly social speeies—perform their humble parts in the economy of nature without teaching or example, for they are, for the most part, born orphans, and without relatives having experience to communicate. The progeny of each year begins its independent cycle anew. Yet every individual performs more or less perfectly the allotted part, as did its ancestors for generation after generation. The correct view of the matter, and one which completely refutes the more common idea of the fixity of instinct, is that a certain number of individuals are, in point of fact, constantly departing from the lines of action and variation most useful to the species, and that these are the individuals which fail to perpetuate their kind and become eliminated through the general law of natural selection."

"Whether these actions be purely unconscious and automatic or more or less intelligent and conscious does not alter the fact that they are necessarily inherited. The habits and qualities that have been acquired by the individuals of each generation could have become fixed in no other way than through heredity. Many of these acts, which older naturalists explained by that evasive word "instinctive," may be the mere unconscious outcome of organization, comparable to vegetative growth; but insects exhibit all degrees of intelligence in their habits and actions, and they perform acts which, however voluntary and, as I believe, conscious in many cases, as that of our Yucca Moth, could not be performed were the tendency not inherited. Every larva which spins or constructs a hibernaculum, or a cocoon in which to undergo its transformations, exemplifies the power of heredity in transmitting acquired peculiarities. A hundred species of parasitic larvæ, *e. g.*, of the family Braconidæ, which in themselves are almost or quite indistinguishable from one another structurally, will nevertheless construct a hundred distinctive cocoons—differing in form, in texture, in color, and in marking—each characteristic of its own species and in many instances showing remarkable architectural structures, and can have little or nothing to do with the mere organization or form or structure of the larva, but they illustrate in the most convincing manner the fact that the tendency to construct and the power to construct the cocoon after some definite plan must be fixed by heredity, since there is no other way of accounting for it. This fact alone, which no one seems to have thought of in the discussion, should be sufficient to confound the advocates of the non-transmissibility of acquired characteristics."

"Thus to my view modification has gone on in the past, as it is going on at the present time, primarily through heredity in the insect world. I recognize the physical influence of environment; I recognize the effect of the interrelation of organisms; I recognize, even to a degree that few others do, the psychic influence, especially in higher organisms—the power of mind, will, effort, or the action of the individual as contradistinguished from the action of the environment; I recognize the influence of natural selection, properly limited; but above all, as making effective and as fixing and accumulating the various modifications due to these or whatever other influences, I recognize the power of heredity, without which only the first of the influences mentioned can be permanently operative."

THE PHYSIOLOGICAL BASIS OF FEELINGS.[1]

Thanks to the revolutionizing movement in modern discoveries, Psychology now ranks as an exact science. Investigations of the physiological basis of consciousness on the one side and the establishment of a mathematical relation of the phenomena of consciousness to the phenomena of the external world on the other, are the two factors that have done much to accomplish the result.

Yet these two factors are not sufficient to lift all psychology out of the slough of metaphysics and establish it upon the firm rock of natural science. True it is that these two things we owe to psycho-physics and physiological-psychology. But psycho-physics and physiological-psychology are not the whole content of the sphere of psychology. They form but a part of that sphere—a large part it is true, yet still only a part.

It is the province of psychology to solve all psychological problems upon an experimental basis. It is also the purpose of psychology to treat the conscious states as such; to note their effects, and to trace them to their elements. Here it is that psychology transcends psycho-physics and physiological psychology. Although experiments may teach us what strength of a stimulus will produce pleasure, what strength will produce pain, and what strength will produce paralysis—yet no experiment can ever tell us why a given excitation sometimes produces one sensation and sometimes another.

The two vital problems for psychogists are: 1. What psychical activities does a new born babe possess? 2. How are the psychical functions of the adult derived from these?

The province of psychology is like the province of anatomy. The descriptive anatomist studies the body as it is at a certain stage in its development. Likewise the psychologist investigates the elements in any given psychical state. But the province of anatomy is broader than this. The anatomist must study embryology. He must show how the uniform mass of protoplasm called an egg is gradually transformed into a mass of cells. He must show how this undifferentiated mass of cells splits up into three germ layers. He must show how these germ layers differentiate into the various organs of the body. In short the anatomist must show how the present condition of the body has been evolved from some

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1. KROENER EUGEN. Das koerperliche Gefuehl. Breslau, 1887. Translated and abstracted by Chas. H. Turner, M.S., Univ. of Cincinnati.

past condition. The path of the psychologist runs parallel to this. The psychologist must show how the present human psychical activities have been derived from simpler psychical activities. It is evident that this genetic-psychology must go hand in hand with physiological-psychology. When these two are united psychology is raised to the dignity of an exact science.

PSYCHOLOGY AS METAPHYSICAL AND EMPIRICAL.—Early psychologists spent their time discussing the nature of the soul and its relation to the body. Death focused the popular mind upon the soul. They saw that the corpse lacked something which the living possessed. This missing factor was called the soul or spirit.

The soul was conceived to be a rarified body like air. But air was not rare enough to suit the philosophers. Soon they dethroned air and set up fire. But neither air nor fire was subtle enough to suit Anaxagoras. He cast both aside and said that the soul was immaterial. He spoke and dualism was issued into the world. Side by side with dualism has gone monism. Both theories are with us to-day. Standing opposed to dualism we have monistic materialism.

Empirical psychology must turn its back upon all such metaphysical subtleties. Yet in doing so it is not necessary to abandon the words "soul" and "spirit."

Psychology treats of certain well-marked phenomena; we have the same right to call these manifestations psychical as he have to call others chemical or physical. We must only remember that the word "soul" means a collection of phenomena and not a transcendental body. We may even speak of the interaction of soul and body, providing we predicate nothing as to the nature of that soul.

Herbart insists upon the unity and simplicity of the soul. According to him it is an error to speak of the powers of the soul. There is some truth in this. But just as we use the terms force of gravity, etc., as makeshift explanations of physical phenomena, so we may use powers of the soul as makeshift explanations of psychical things.

The steps in the development of consciousness, in either the individual or the race, are not so clear cut as the rounds of a ladder. In this communication the first stage in the evolution of mind is discussed. Here feeling preponderates over the other two elements. Yet it will be necessary to extend investigations into the realm of cognition and of volition.

Hand in hand with physiological-psychological analysis of feeling must go a study of the biological significance of feeling.

APPLICATION OF EMBRYOLOGY TO PSYCHOLOGY.—The study of the development of the human soul is beset with perplexities. The suckling movements of a new born babe are full of purpose. Is this reaching after the mother's breast the resultant of vague knowledge or of reflex action? Is it simple or complex? These two probabilities confront us at every step. They may be symbolized as follows: Let $R =$ the excitation; $c =$ sensory nerve centre of first order; $c^1 =$ motor nerve centre of same rank; $C =$ sensory nerve centre of higher order; $C^1 =$ motor nerve centre of higher order; $m =$ resultant movement; then will $R\ c\ c^1\ m$ symbolize reflex action, and $R\ c\ C\ C^1\ c^1\ m$, symbolize conscious action.

Neither the suckling movement nor any other infantine movement solves this difficulty.

What shall we say about purposeless movements? Most infantine activities are of this class. All we can say is that the child has agreeable or disagreeable feelings and acts accordingly.

All in all the infant's mind is far too advanced to throw much light upon its origin. Although apparently primitive, the infantine mind has the same physiological basis as the adult mind. If we wish to gain an insight into the origin of the psychical activities of man we must dive deeper than the mind of the human babe. Yes, much deeper. We must pass below the mammals, with their complex nervous systems, to forms with simple nervous systems.

Here we meet opposition. All do not admit that the lower animals have a soul. Descartes asserts that man is the only creature in the universe endowed with a soul. To him all the lower animals are machines. Aristotle, although recognizing an evolution, says: "Plants vegetate, animals vegetate and move, man vegetates, moves and thinks. This was long ago. To-day it is beginning to be seen that all the psychical activities of man are derived from the psychical activities of the lower animals.

As has been said, the aim of psychology is to trace psychological activities from their lowest to their highest manifestations. In the past nothing was done in this direction. Then psychology was partly metaphysical (rational psychology); partly merely descriptive (empirical psychology); partly analytic. The last is far superior to the other two. By its means psychical processes were reduced to their elements. This was a great step in advance. But psychology had not yet reached its goal. As in zoology and botany, so here analysis and synthesis must go hand in hand. Questions of ontogeny cannot be solved without the help of observations upon the phylogeny. What Darwin has done for Biology, Wundt and his followers are doing for Psychology.

If from a morphological standpoint the higher and lower animals stand in a causal relation to each other, then we have reason to suppose that from a psychological standpoint the same is true. Darwinism, if a fact, must embrace all creation, mind as well as body. As far as the body is concerned, Darwinism is well established. But little has yet been done on the other side.

Physiology often establishes laws which further psychology. One of the choicest fruits of physiology is Haeckel's statement that "The ontogenetic development of the individual is a rapid and compact repetition of the phylogenetic development of the species." Applied to mind this law reads as fallows: "The ontogenetic development of the human mind is a rapid and compact repetition of the phylogenetic development of mind in the animal kingdom. This law is far-reaching.

1. When the psychical activities of a simple organism are known, this known function gives a clue for analyzing the simplest psychical activities of a complex organism.

2. When by an analysis psychological research has reached an elementary function of the human mind, comparison of this element with the mind of a much lower organism will test the accuracy of the analysis.

3. In the animal kingdom it appears that a certain psychical phenomenon appears at a certain phylogenetic stage. Here we have a clue to the ontogenetic stage at which it appears in man, and also the path along which it appears in man, and also the path along which research must plod.

4. On the other hand, from the first appearance of a psychical phenomenon in an ontogenetic series we may argue when it appears in the phylogenetic series.

5. The old time dispute over "instinct" and "intellect" can be solved along this line.

But we must be cautious. We must not use this law blindly. All Darwinism, especially this fundamental law of biology, is for psychology a convenient working hypothesis.

To make my meaning clearr; finding that feeling predominates in the lower form, I am directed to search and see if feeling plays the same role in the new born human babe.

It must ever be borne in mind that Darwinism is of no service whatsoever in solving metaphysical problems. What is the nature of the soul? Is it material or spiritual? monistic or dualistic? All these are questions in which psychology, as a natural science, must not dabble.

There is one difference between the morpho-physiological and the psychical evolution. In the former almost all the parallels between the ontogenetic and the phylogenetic development have been passed by the time of birth. In the psychical development it takes a much longer time to accomplish this.

WHAT IS FEELING? The definitious of feelings are as varied as they are numerous.

Aristotle says that feelings are dependant upon thought. As sensation has been likened to simple thought so the feeling of pleasure and pain is compared to affirmation and negation. Feeling is subordinate to desire. Thus speaks Aristotle. How could he have formed a different opinion? He had studied only the highly differentiated feelings—the so-called spiritual feelings. Here feeling easily appears to be a mere appendix to the presentation activities, for here feeling is based upon thought. But Aristotle was mistaken, he was traveling the wrong path. Yet many thinkers have followed in his footsteps.

At a middle point in the evolution of psychology, the Cognition Theory, with *Descartes* at its head, entered the world. This theory is permeated with metaphysical suppositions. Remove the metaphysical subtleties and the riddled structure crumbles into dust. Descartes investigated the question as to the certainty of our cognitions. All psychical activities are subordinated to the presentation activities. According to him, we have three kinds of perceptions: 1st, such as have their origin in the external world; 2d, such as have their origin in the body; 3d, such as have their origin in the mind. The first class are the sense perceptions, the second class are the bodily feelings; the third class are the spiritual feelings.

Spinoza defines feelings as the *passio animae*, whereby the mind does not attain either its highest or its lowest perfection. He deals with the higher feelings only. With Spinoza, joy, sadness, and desire are primitive feelings.

Hobbes sought to make a clearer presentation of feeling. He sought a physiological basis for feeling. A material called animal spirits flowed through the nerves to the brain, there it aroused sensation. Continuing in its course the stream passes from the brain to the heart. There it arouses feelings. This is all pure nonsense, yet it is a step in the right direction. It is a step towards a true explanation, which is much more than can be said of the definitions of either Descartes or Spinoza.

Locke speaks clearly from an intellectual standpoint. Man is joyful when he knows that he has accomplished something good. He is sad when he has done evil. Joy and sorrow accompany the knowledge of his acts.

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Wolff and his school follow in the footsteps of Locke.

Herbart's view is an outgrowth of his polemic against distinct faculties of the soul combined with his opinion as to the nature of the presentations. He traced both feelings and the effects of feeling back to the relations of many presentations, which presentations do not appear singly and which, perhaps, cannot become perceptions. To support this view, Herbart had resort to the aesthetic feelings. This view gives no conception whatever of the bodily feeling. It does not state clearly what relation a feeling sustains to a single presentation.

GENERAL FEELING. By general feelings are meant all those feelings which pertain to the body as a whole and not to my special organ or group of organs. Yet some so-called general feelings are always more or less localized. Pain is always localized. If a sensory nerve is irritated in its course, pain is localized at the extremity of that nerve. Men with amputated limbs feel intense irritation of the nerve stump as pain at the spot where the nerve originally terminated.

On the other hand, feelings of comfort or discomfort are never localized. They involve the whole body. It is the same with the emotions. In the last case two factors are involved; viz: 1st, a bodily general feeling, either as a cause or an effect; 2d, the course and content of the thought. Such feeling can never be localized. Here then is a marked contrast between pain and discomfort. Pain is always localized, discomfort is never localized.

Wundt considers the general sensation the prime cause of the general feeling. He makes general feeling the last member of a long series of processes.

The general feeling may be designated as the feeling which affects not only a definite group of nerves, but which causes similar alterations in the whole nervous system.

We may also designate general feelings as all unlocalized physiological affectations of the consciousness which are of an agreeable or disagreeable character. This definition excludes pain, tickling and organic sensations.

In spite of this endeavor to separate general from localized feelings, it must not be supposed that the two are never united. Tooth-ache is a localized feeling, yet with it goes a general feeling which affects not only the diseased part, but the whole body.

FIRST TRACES OF MIND. It is a bright day. The sun falls upon tbe body. A portion of the light is absorbed, a portion reflected. A few rays enter the eye, impinge upon the retina and send an excitation to the brain. The mind is affected. Immediately processes spring into action which from a physiological stand-point have no existence whatsoever. We see, not the flat image which is produced on the retina, but a body having a definite form, size and perspective. Here we have three factors at work: 1st, the external excitation; 2d, the physiological intermedia; 3d, the psychical processes. In researches upon feeling, as well as upon all other psychical states, these three factors must be investigated.

The question arises, how do we know that there is such a thing as feeling? Self observation tells us so. Just so certainly as I know that I think, just so certainly do I know that I feel thus or so. Observation of the actions and writings of other men lead to the same result. So do studies of the actions of the lower animals. Indeed, in the lower animals feeling predominates over the other factors. Here then is the best field for the study of feeling.

The question now arises, how far down the scale shall we push our researches? Where in the evolution of life does mind first appear? Where in the development of the individual does mind first appear? There is no royal road to the solution of this question; no criterion by which to tell the conscious from the unconscious being. True, all conscious beings are capable of movements. But all movements do not indicate a mind. During a cyclone, rocks and trees perform many gymnastic feats; but no one would call those movements conscious? When some of the lower animals seek the light while others shrink from it, are their movements dictated by a mind? Such questions form the gordian knot of psychology. Unaided psychology cannot solve these questions. Let us call physiology to her aid.

The basis of man's consciousness is a central nervous system, consisting of a brain and a spinal cord. Wherever we find such a nervous system the probability is that there we will find a mind also. Lower down in the scale we find that the higher invertebrates possess a nervous system that differs essentially from the vertebrate nervous system. It consists of chains of ganglia grouped in various ways in different cases. But some of the invertebrates display undoubted intellectual traits. Recall the ants and bees. Since the neurological basis of consciousness is the same in all higher invertebrates, we may conclude that they all have a mind. Among animals that have no nervous systems are the infusoria. Here the so-called courting movements indicate a mind.[1] Lower than the infusoria we find no movements that appear to be due to consciousness. Since there is no essential physical difference between the infusoria and the lower protozoans, why draw a line in the psychical world. In the physical world there has been a gradual transition from lower to higher forms, why not have the same in the psychical world.

Fechner has predicated a soul of plants, certainly it is a difficult matter to separate plants from animals.[2] If plants have a mind, feeling is the predominating element.

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[1] All Biologists would not agree with Kroener here. Some would think the locomotive movements and the feeding movements of these animals were more indicative of consciousness than the so-called courting movements. But such discrepancies are to be expected. As Morgan would say, it is no easy matter to eject correctly when the organism is morphologically at so great a remove.

[2] The manner in whsch certain plants (Drosera, Dionea) entrap insects and then cast away the "bones" when they are satiated; the manner in which the dandelion erects its head until its flowers are fertilized by insects; then lowers its head until the seed are matured, and then re-erects it to have the seed scattered by the wind, are all things that seem as much indicative of consciousness as many examples cited by Kroener as indicating a mind in the protozoans. Furthermore, the changes plants have undergone in the struggle for existence, are as much indicative of mind as the majority of the changes that the lower animals have undergone. Kroener, however, does not think that plants have a mind.

It is thought that we may safely conclude:

1. Wherever there is a central nervous system, there we find a consciousness.

2. Consciousness may be traced backward, through animals with simple nervous systems, to animals with none at all.

3. An absolute boundary between consciousness and unconsciousness cannot be drawn. Probably consciousness begins with the dawn of life.

4. Probably the evolution ot the soul goes hand in hand with the evolution of the nervous system.

GENERAL FEELING THE FUNCTION OF MIND IN THE PHYLOGENETIC DEVELOPMENT. The movements of the sensitive plants are due to mechanical stimuli. The turning of plants to the light is due to the effect of light. The opening of some flowers during the day and of others during the night is due to chemical stimuli originated by light.[1] In insectivorous plants, the folding of the parts is mechanical, but the resting of the organ in a folded state is a secondary acquirement.[2]

If we regard insectivorous plants as conscious beings then we must introduce between the mechanical stimulus and the capturing movements and digestive activities a psychical state. Such a state corresponds to the appetite aroused in us by the odor of a good meal; or, better still, by the appetite aroused in the new born babe by the proximity of its mother's breast. This would be a general feeling aroused by chemical stimuli. These observations show that plants have states which prefigure the conscious states of the lower animals. It must be carried in mind, however, that plants have no sense-perceptions. They have no sense organs, and sense organs are essential to sense-perceptions.

In the lowest protozoa, the monera of Haeckel, consciousness can scarcely be said to be more highly developed than in the plants. Here then we find feelings only and no sense-perceptions. Indeed, how could they have sense-perceptions? To develop a sense two factors must come

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[1] It seems as though there is something more than this. Is there enough difference in the chemical constitution of different plants to warrant such opposite reactions to the same stimuli?

[2] Kroener seems to ignore the fact that insectivorous plants contract under the stimulus of nitrogenous material, and that the continued excitation due to the presence of this food retains the parts in a contracted state until the nitrogenous material is digested.

into play—exercise and heredity. In case of the monera the external stimuli are too uniform and the duration of life too short for exercise to devevelop a sense.[1] Heredity is, of course, out of the question.

The first two steps in the morphological development of higher animals from the monera are of psychological importance. The first advance is the formation of a dense external coat. Thus we have a shutting off of the animal from the external world. The first step towards the recognition of an outer world has been taken. Now the protoplasm becomes more granular. Differentiation has begun and the first steps towards the evolution of a nervous system have been taken. But after all this, still the infusoria have not advanced far enough to have sense-perceptions. To be sure, in a few cases infusoria have sensitive pigment flecks. But these probably arouse feelings only.

GENERAL FEELINGS THE FIRST ACTIVITY OF MIND IN THE ONTOGENETIC DEVELOPMENT. We now stand on slippery ground. Many believe that man's psychical life begins at birth; and that all his previous existence was a mere vegative life. But no sharp line can be drawn between vegetative and animal functions. And the theory of evolution leads us to believe that, as in the lower animals, so here there is a trace of consciousness even at the beginning.

The supposition that the mind appears at birth presupposes one of two things. Either the mind is a product af external activities or else there is a predetermined harmony which determines that the babe shall be born at a certain definite time, and that that time shall be characterized by the appearance of mind. But the period of pregnancy varies in different individuals, and in the same individual at different times. This fact is a death blow to the predetermined harmony theory.

Many facts have led a few to believe that consciousness is present long before birth. *Romanes* thinks that at birth man has reached a mental development equal to that of an adult coelenterate, *C. J. Carus* believes that at birth man is psychologically the equal of adult annelids and mollusks.

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[1] Weismann claims that the infusoria are potentially immortal and that the infusoria here to-day, accident excepted, have been here ever since the beginning of infusorian life It has been shown, however, that without sexual union these forms do die in course of time. But even here we have the same individual, receiving additions from time to time, yet living on indefinitely, providing no accident occurs. It seems then that "lack of time in which to accomplish the changes necessary to originate a sense" must be dropped.

Be this as it may, anatomy supports the view that consciousness appears before birth. We find in the human embryo not only vegetative but also motor activities—the fœtal movements. These movements cannot be due to mechanical stimuli,for they occur even when the mother is resting. Light and temperature are excluded. Chemical stimuli are the main cause of the movements. But in the lower animals chemical stimuli are the main source of the general feelings. Here then, as lower down, it is probable that chemical stimuli originate the first general feelings.

At birth the babe is subjected to a new series of stimuli. All these at first originate general feelings only. When light first falls upon the retina the child closes the eyelids. Evidently the child is expressing discomfort. Here then we have a general feeling before the sensation of sight. It is so with all the senses. We cannot have a sense-perception until we learn to associate inner changes with external stimuli.

Hence we see that in the ontogonetic as well as the phylogenetic development, the general feelings are the first psychical faculties to appear.

THE MOST PROMINENT GENERAL FEELINGS. These are the organic feelings and the general feelings of the various senses.

The *organic feelings* may be divided into two divisions, (a) organic feelings of the vegetative system; (b) organic feelings of the animal system.

Under organic feelings of the vegetative system are classed all those feelings which radiate from the respiratory or digestive systems.

The normal functioning of the respiratory system is accompanied by no feelings. But the moment it functions wrongly an unpleasant feeling arises. Every chemical change in the air breathed arouses a general feeling. A change from foul to pure air arouses a feeling of pleasure. A change from pure to foul air arouses a feeling of pain. Under this head are classed: headache, oppression, distraction, etc. All these are caused by improper diffusion of gas and conseqent blood poisoning. Some animals are so affected by changes in the atmosphere that they can predict the weather.

When feelings accompany digestion they are usually of an unpleasant character. When the body's demand for food exceeds the supply, hunger ensues. Hypochondria is the child of bad digestion. This is proved by the fact that hypochondriacs are often cured by putting the digestive apparatus in order.

Under organic feelings of the animal system we class fatigue and sleepiness. Fatigue has its origin in muscular exhaustion, while sleepiness has its origin in nervous exhaustion.

General Feelings of the Sense Organs—Epidermal Sense. All of the special senses have been evolved out of the epidermal sense. Among the lower animals the chemical sense is an epidermal sense and as such originates general feelings. In the phylogenetic development the major portion of the epidermal sense is evolved into the special senses. A trace of this sense persists, however, and this it is which enables the blind to have a perception of the color of the environment.

Excepting as idiosyncrasies, the sense of touch and temperature never arouse general feeling in either man or the higher animals. Some people cannot bear to stroke with the hand, either silk or plush. Others shudder when they bite certain substances. This shuddering is the expression of something intermediate between general feelings and sense feelings.

General Feelings of the Chemical Sense. All animals are endowed with a chemical sense. In the lower animals and in a young human babe this sense is chiefly concerned with nourishment. One of the first acts of a new born babe is to seek its mother's breast. It has already been stated that this is probably prompted by a general feeling. Experiments upon the higher mammals show that here the sense of smell plays an important role. If the olfactory nerves of a young pup be cut, the pup does not find its mother's breast.

Sympathy and antipathy are often the off-springs of the sense of smell. By this sense ants distinguish intruders from the natives of the nest. Woe to the victim thus discovered! The back of a dog was stroked with the hand. The hand was then placed in a basket containing blind three day old kittens. Immediately the kittens began spitting and arching the back. Thus the mere odor of a dog engendered fear in kittens that had never seen a dog.

At first these feelings are pure. Later presentations are associated with them. In the arms of one person a child will cry. Under exactly the same circumstances, but in different arms, the child will be happy.

The general feelings of the sense of taste are closely allied to those of the sense of smell. The sense of taste plays an important role in the sexual life.

General Feelings of Sense of Hearing. In man the general feelings accompanying hearing are idiosyncrasies. Some people cannot bear to hear a gritty sponge rubbed across a slate; others cannot bear to hear a person bite an apple; while others cannot bear to hear a person grit his teeth.

In the animal kingdom, the general feelings accompanying hearing have a great bearing upon sexual selection.

General Feelings of the Sense of Sight. The general feeling accompaning sight are more varied than those accompaning hearing. The lowest animals have no sense of sight, yet they experience light excitations. Physiological results of these excitations are found even in the infusoria. Ehrenberg found that the Euglena sought the light. Other infusoria shrink away from the light. It seems highly probably that in these cases the movements were originated by general feelings. In the first case light aroused pleasant feelings, while in the second case light aroused unpleasant feelings. Colors arouse general feelings in some organisms. According to Englemann, Euglena prefers blue. In birds the feeling aroused by colors play an important role in sexual selection. Many animals and a few varieties of savages are enraged whenever they see red. On the other hand yellow produces hatred because so many poisonous animals are of that color.

EMOTIONS. Emotions may be defined as general feelings bound up with definite associations of ideas in such a manner that either directly or indirectly both are called up by the same object.

There is a difference between emotion and impulse. In the emotions, the presentations cause internal reactions; while in impulse the presentations originate movements.

Very frequently emotions pass imperceptibly into emotions of the opposite kind. Animals very frequently change their playful nibblings into serious biting. Witness a child at play. One moment it is full of joy. The next it is crying bitterly. Nervous people very often pass from a fit of laughter to a fit of crying. Pain caused by the death of a loved one passes into mourning; mourning into melancholy; and melancholy into a half joyful, loving remembrance. Anger often begins in a joyful feeling. Thus, we see that we cannot divide emotions into joyful and sorrowful, for most emotions combine both feelings. We often see a child undetermined whether to laugh or to cry. Such a child is experiencing a mixed feeling.

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Herbart's view is an outgrowth of his polemic against distinct faculties of the soul combined with his opinion as to the nature of the presentations. He traced both feelings and the effects of feeling back to the relations of many presentations, which presentations do not appear singly and which, perhaps, cannot become perceptions. To support this view, Herbart had resort to the aesthetic feelings. This view gives no conception whatever of the bodily feeling. It does not state clearly what relation a feeling sustains to a single presentation.

GENERAL FEELING. By general feelings are meant all those feelings which pertain to the body as a whole and not to my special organ or group of organs. Yet some so-called general feelings are always more or less localized. Pain is always localized. If a sensory nerve is irritated in its course, pain is localized at the extremity of that nerve. Men with amputated limbs feel intense irritation of the nerve stump as pain at the spot where the nerve originally terminated.

On the other hand, feelings of comfort or discomfort are never localized. They involve the whole body. It is the same with the emotions. In the last case two factors are involved; viz: 1st, a bodily general feeling, either as a cause or an effect; 2d, the course and content of the thought. Such feeling can never be localized. Here then is a marked contrast between pain and discomfort. Pain is always localized, discomfort is never localized.

Wundt considers the general sensation the prime cause of the general feeling. He makes general feeling the last member of a long series of processes.

The general feeling may be designated as the feeling which affects not only a definite group of nerves, but which causes similar alterations in the whole nervous system.

We may also designate general feelings as all unlocalized physiological affectations of the consciousness which are of an agreeable or disagreeable character. This definition excludes pain, tickling and organic sensations.

In spite of this endeavor to separate general from localized feelings, it must not be supposed that the two are never united. Tooth-ache is a localized feeling, yet with it goes a general feeling which affects not only the diseased part, but the whole body.

First Traces of Mind. It is a bright day. The sun falls upon the body. A portion of the light is absorbed, a portion reflected. A few rays enter the eye, impinge upon the retina and send an excitation to the brain. The mind is affected. Immediately processes spring into action which from a physiological stand-point have no existence whatsoever. We see, not the flat image which is produced on the retina, but a body having a definite form, size and perspective. Here we have three factors at work: 1st, the external excitation; 2d, the physiological intermedia; 3d, the psychical processes. In researches upon feeling, as well as upon all other psychical states, these three factors must be investigated.

The question arises, how do we know that there is such a thing as feeling? Self observation tells us so. Just so certainly as I know that I think, just so certainly do I know that I feel thus or so. Observation of the actions and writings of other men lead to the same result. So do studies of the actions of the lower animals. Indeed, in the lower animals feeling predominates over the other factors. Here then is the best field for the study of feeling.

The question now arises, how far down the scale shall we push our researches? Where in the evolution of life does mind first appear? Where in the development of the individual does mind first appear? There is no royal road to the solution of this question; no criterion by which to tell the conscious from the unconscious being. True, all conscious beings are capable of movements. But all movements do not indicate a mind. During a cyclone, rocks and trees perform many gymnastic feats; but no one would call those movements conscious? When some of the lower animals seek the light while others shrink from it, are their movements dictated by a mind? Such questions form the gordian knot of psychology. Unaided psychology cannot solve these questions. Let us call physiology to her aid.

The basis of man's consciousness is a central nervous system, consisting of a brain and a spinal cord. Wherever we find such a nervous system the probability is that there we will find a mind also. Lower down in the scale we find that the higher invertebrates possess a nervous system that differs essentially from the vertebrate nervous system. It consists of chains of ganglia grouped in various ways in different cases. But some of the invertebrates display undoubted intellectual traits. Recall the ants and bees. Since the neurological basis of consciousness is the same in all higher invertebrates, we may conclude that they all have a mind. Among animals that have no nervous systems are the infusoria. Here the so-called courting movements indicate a mind.[1] Lower than the infusoria we find no movements that appear to be due to consciousness. Since there is no essential physical difference between the infusoria and the lower protozoans, why draw a line in the psychical world. In the physical world there has been a gradual transition from lower to higher forms, why not have the same in the psychical world.

Fechner has predicated a soul of plants, certainly it is a difficult matter to separate plants from animals.[2] If plants have a mind, feeling is the predominating element.

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[1] All Biologists would not agree with Kroener here. Some would think the locomotive movements and the feeding movements of these animals were more indicative of consciousness than the so-called courting movements. But such discrepancies are to be expected. As Morgan would say, it is no easy matter to eject correctly when the organism is morphologically at so great a remove.

[2] The manner in which certain plants (Drosera, Dionea) entrap insects and then cast away the "bones" when they are satiated; the manner in which the dandelion erects its head until its flowers are fertilized by insects; then lowers its head until the seed are matured, and then re-erects it to have the seed scattered by the wind, are all things that seem as much indicative of consciousness as many examples cited by Kroener as indicating a mind in the protozoans. Furthermore, the changes plants have undergone in the struggle for existence, are as much indicative of mind as the majority of the changes that the lower animals have undergone. Kroener, however, does not think that plants have a mind.

It is thought that we may safely conclude:

1. Wherever there is a central nervous system, there we find a consciousness.

2. Consciousness may be traced backward, through animals with simple nervous systems, to animals with none at all.

3. An absolute boundary between consciousness and unconsciousness cannot be drawn. Probably consciousness begins with the dawn of life.

4. Probably the evolution ot the soul goes hand in hand with the evolution of the nervous system.

GENERAL FEELING THE FUNCTION OF MIND IN THE PHYLOGENETIC DEVELOPMENT. The movements of the sensitive plants are due to mechanical stimuli. The turning of plants to the light is due to the effect of light. The opening of some flowers during the day and of others during the night is due to chemical stimuli originated by light.[1] In insectivorous plants, the folding of the parts is mechanical, but the resting of the organ in a folded state is a secondary acquirement.[2]

If we regard insectivorous plants as conscious beings then we must introduce between the mechanical stimulus and the capturing movements and digestive activities a psychical state. Such a state corresponds to the appetite aroused in us by the odor of a good meal; or, better still, by the appetite aroused in the new born babe by the proximity of its mother's breast. This would be a general feeling aroused by chemical stimuli. These observations show that plants have states which prefigure the conscious states of the lower animals. It must be carried in mind, however, that plants have no sense-perceptions. They have no sense organs, and sense organs are essential to sense-perceptions.

In the lowest protozoa, the monera of Haeckel, consciousness can scarcely be said to be more highly developed than in the plants. Here then we find feelings only and no sense-perceptions. Indeed, how could they have sense-perceptions? To develop a sense two factors must come

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[1] It seems as though there is something more than this. Is there enough difference in the chemical constitution of different plants to warrant such opposite reactions to the same stimuli?

[2] Kroener seems to ignore the fact that insectivorous plants contract under the stimulus of nitrogenous material, and that the continued excitation due to the presence of this food retains the parts in a contracted state until the nitrogenous material is digested.

into play—exercise and heredity. In case of the monera the external stimuli are too uniform and the duration of life too short for exercise to devevelop a sense.[1] Heredity is, of course, out of the question.

The first two steps in the morphological development of higher animals from the monera are of psychological importance. The first advance is the formation of a dense external coat. Thus we have a shutting off of the animal from the external world. The first step towards the recognition of an outer world has been taken. Now the protoplasm becomes more granular. Differentiation has begun and the first steps towards the evolution of a nervous system have been taken. But after all this, still the infusoria have not advanced far enough to have sense-perceptions. To be sure, in a few cases infusoria have sensitive pigment flecks. But these probably arouse feelings only.

GENERAL FEELINGS THE FIRST ACTIVITY OF MIND IN THE ONTOGENETIC DEVELOPMENT. We now stand on slippery ground. Many believe that man's psychical life begins at birth; and that all his previous existence was a mere vegative life. But no sharp line can be drawn between vegetative and animal functions. And the theory of evolution leads us to believe that, as in the lower animals, so here there is a trace of consciousness even at the beginning.

The supposition that the mind appears at birth presupposes one of two things. Either the mind is a product af external activities or else there is a predetermined harmony which determines that the babe shall be born at a certain definite time, and that that time shall be characterized by the appearance of mind. But the period of pregnancy varies in different individuals, and in the same individual at different times. This fact is a death blow to the predetermined harmony theory.

Many facts have led a few to believe that consciousness is present long before birth. *Romanes* thinks that at birth man has reached a mental development equal to that of an adult coelenterate, *C. J. Carus* believes that at birth man is psychologically the equal of adult annelids and mollusks.

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[1] Weismann claims that the infusoria are potentially immortal and that the infusoria here to-day, accident excepted, have been here ever since the beginning of infusorian life It has been shown, however, that without sexual union these forms do die in course of time. But even here we have the same individual, receiving additions from time to time, yet living on indefinitely, providing no accident occurs. It seems then that "lack of time in which to accomplish the changes necessary to originate a sense" must be dropped.

Be this as it may, anatomy supports the view that consciousness appears before birth. We find in the human embryo not only vegetative but also motor activities—the fœtal movements. These movements cannot be due to mechanical stimuli,for they occur even when the mother is resting. Light and temperature are excluded. Chemical stimuli are the main cause of the movements. But in the lower animals chemical stimuli are the main source of the general feelings. Here then, as lower down, it is probable that chemical stimuli originate the first general feelings.

At birth the babe is subjected to a new series of stimuli. All these at first originate general feelings only. When light first falls upon the retina the child closes the eyelids. Evidently the child is expressing discomfort. Here then we have a general feeling before the sensation of sight. It is so with all the senses. We cannot have a sense-perception until we learn to associate inner changes with external stimuli.

Hence we see that in the ontogonetic as well as the phylogenetic development, the general feelings are the first psychical faculties to appear.

THE MOST PROMINENT GENERAL FEELINGS. These are the organic feelings and the general feelings of the various senses.

The *organic feelings* may be divided into two divisions, (a) organic feelings of the vegetative system; (b) organic feelings of the animal system.

Under organic feelings of the vegetative system are classed all those feelings which radiate from the respiratory or digestive systems.

The normal functioning of the respiratory system is accompanied by no feelings. But the moment it functions wrongly an unpleasant feeling arises. Every chemical change in the air breathed arouses a general feeling. A change from foul to pure air arouses a feeling of pleasure. A change from pure to foul air arouses a feeling of pain. Under this head are classed: headache, oppression, distraction, etc. All these are caused by improper diffusion of gas and conseqent blood poisoning. Some animals are so affected by changes in the atmosphere that they can predict the weather.

When feelings accompany digestion they are usually of an unpleasant character. When the body's demand for food exceeds the supply, hunger ensues. Hypochondria is the child of bad digestion. This is proved by the fact that hypochondriacs are often cured by putting the digestive apparatus in order.

Under organic feelings of the animal system we class fatigue and sleepiness. Fatigue has its origin in muscular exhaustion, while sleepiness has its origin in nervous exhaustion.

General Feelings of the Sense Organs—Epidermal Sense. All of the special senses have been evolved out of the epidermal sense. Among the lower animals the chemical sense is an epidermal sense and as such originates general feelings. In the phylogenetic development the major portion of the epidermal sense is evolved into the special senses. A trace of this sense persists, however, and this it is which enables the blind to have a perception of the color of the environment.

Excepting as idiosyncrasies, the sense of touch and temperature never arouse general feeling in either man or the higher animals. Some people cannot bear to stroke with the hand, either silk or plush. Others shudder when they bite certain substances. This shuddering is the expression of something intermediate between general feelings and sense feelings.

General Feelings of the Chemical Sense. All animals are endowed with a chemical sense. In the lower animals and in a young human babe this sense is chiefly concerned with nourishment. One of the first acts of a new born babe is to seek its mother's breast. It has already been stated that this is probably prompted by a general feeling. Experiments upon the higher mammals show that here the sense of smell plays an important role. If the olfactory nerves of a young pup be cut, the pup does not find its mother's breast.

Sympathy and antipathy are often the off-springs of the sense of smell. By this sense ants distinguish intruders from the natives of the nest. Woe to the victim thus discovered! The back of a dog was stroked with the hand. The hand was then placed in a basket containing blind three day old kittens. Immediately the kittens began spitting and arching the back. Thus the mere odor of a dog engendered fear in kittens that had never seen a dog.

At first these feelings are pure. Later presentations are associated with them. In the arms of one person a child will cry. Under exactly the same circumstances, but in different arms, the child will be happy.

The general feelings of the sense of taste are closely allied to those of the sense of smell. The sense of taste plays an important role in the sexual life.

General Feelings of Sense of Hearing. In man the general feelings accompanying hearing are idiosyncrasies. Some people cannot bear to hear a gritty sponge rubbed across a slate; others cannot bear to hear a person bite an apple; while others cannot bear to hear a person grit his teeth.

In the animal kingdom, the general feelings accompanying hearing have a great bearing upon sexual selection.

General Feelings of the Sense of Sight. The general feeling accompaning sight are more varied than those accompaning hearing. The lowest animals have no sense of sight, yet they experience light excitations. Physiological results of these excitations are found even in the infusoria. Ehrenberg found that the Euglena sought the light. Other infusoria shrink away from the light. It seems highly probably that in these cases the movements were originated by general feelings. In the first case light aroused pleasant feelings, while in the second case light aroused unpleasant feelings. Colors arouse general feelings in some organisms. According to Englemann, Euglena prefers blue. In birds the feeling aroused by colors play an important role in sexual selection. Many animals and a few varieties of savages are enraged whenever they see red. On the other hand yellow produces hatred because so many poisonous animals are of that color.

EMOTIONS. Emotions may be defined as general feelings bound up with definite associations of ideas in such a manner that either directly or indirectly both are called up by the same object.

There is a difference between emotion and impulse. In the emotions, the presentations cause internal reactions; while in impulse the presentations originate movements.

Very frequently emotions pass imperceptibly into emotions of the opposite kind. Animals very frequently change their playful nibblings into serious biting. Witness a child at play. One moment it is full of joy. The next it is crying bitterly. Nervous people very often pass from a fit of laughter to a fit of crying. Pain caused by the death of a loved one passes into mourning; mourning into melancholy; and melancholy into a half joyful, loving remembrance. Anger often begins in a joyful feeling. Thus, we see that we cannot divide emotions into joyful and sorrowful, for most emotions combine both feelings. We often see a child undetermined whether to laugh or to cry. Such a child is experiencing a mixed feeling.

Susceptibility to emotions. The physical condition of the body predisposes it to certain emotions. In each individual there is a normal, daily rhythmical fluctuation of the susceptibility to emotions. In the morning, when thought predominates, the susceptibility to emotions of all sorts is feeble. Later the conditions are more favorable to emotions, especially to emotions of an agreeable kind. Immediately after dinner the susceptibility to agreeable emotions is great. When digestion is at its height disagreeable emotions predominate. Evening is the time of tediousness. This explains why people who do not drink stimulants go to bed early.

This rhythmical daily fluctuation in the susceptibility to sensations is dependent partly upon the course of work and partly upon the processes of nutrition. It must not be supposed, however, that these are the only emotion-creating factors. Many other things assist in the work: jewelry, flowers, etc. Pathological states predispose us to emotions. Sickness predisposes one to unpleasant emotions.

Susceptibility to emotions varies with the seasons and the weather. Bad weather fosters anger. Spring brings with it gladness. England, the home of damp, cold fogs, is also the fatherland of that unpleasant disposition we call spleen.

Age alters the attitude towards emotions. Children have but slight emotions of any sort. They are equally susceptible to all emotions. At puberty a new and rich spring of emotions arises. Then is the time of love. In ripe manhood the susceptibility to emotions is much less than in youth. And finally, in old age disagreeable emotions preponderate.

Women are more easily moved to emotions than men. In women, alterations in the sexual conditions causes marked changes in the susceptibility to emotions.

Not only does this susceptibility to emotions vary in the individual at different times, not only does it vary in different sexes, but there are marked differences between individuals. We recognize this when we speak of the temperament of the individual. Indeed, in the inherited temperament of the individual we have a weightier cause of the attitude of the person towards emotions than in any of the causes mentioned.

PHYSIOLOGY OF THE GENERAL FEELING. A careful study of the physiology of this matter leads to the following conclusions:

1. An emotion is a general feeling linked with a definite quality of

the flow of presentations. In lower animals emotions are inseparable from the general feelings.

2. The general feeling is the barrier which separates the emotions from the sense activities. This general feeling rests upon the presence in the entire system of a dissolved or fluid substance.

3. Some emotions, especially in the lower animals, are originated by the penetration of substances from without, while in others they are aroused by a substance in the nervous system being decomposed by psychical shocks.

FEELINGS VS. BODY. In this connection general feeling is used to designate all those feelings which affect the entire body. The general feelings affect all parts of the body and alter their functions. When we experience pleasant feelings all of our organs function more rapidly. When we experience unpleasant feelings, all of our organic functions are retarded.

Special diseases are accompanied by characteristic general feelings. The general feelings also react on the special senses. He who has healthy feeling, sees more keenly, hears more clearly, tastes and smells more acutely and has a more delicate touch than he who is unhealthy. Recall the sparkle in the eye of a healthy man.

Not only do these feelings affect the special senses, but their influence is extended to the voice, to the body. The voice of a healthy man is quite different from that of the sick.

Recall the blush of shame. The radiation of a blush is peculiar. It proceeds from above downward. The stronger the shame the further the blush extends. By partially clothing the body, we have divided it into two portions. The clothed portion loses a part of the reactive activity of the capillaries. Hand in hand with this goes an over excitability of the unclothed portions.

Weeping is caused by the reaction of feelings upon special organs—the lachrymal glands.

SENSE FEELINGS. Both phylogenetically and ontogenetically these feelings rank above the general feelings, They are related to special parts of the body. Yet no sharp line can be drawn between these two classes of feelings. They merge imperceptibly into each other. Some general feelings can almost be localized. Toothache is such a feeling.

Development of Nervous System. It is interesting to note the relations of feelings to the development of the nervous system. In the phylogenetic series, the nervous system first appears as a pigment fleck. Excitations of this spot stimulates changes in the protoplasm. These changes in the course of time result in nerve cells, nerve fibres, muscles and glands.

Every psychological activity, as well as every physiological activity, of the nervous system is determined both by heredity and exercise. Here, as in the physical world, exercise promotes more perfect functioning of all parts. Either over or under exercise brings in its wake unpleasant feelings.

Origin of Sense Feelings. Every feeling of the special senses is composed of three factors: 1st, the external stimulus; 2d, the physiological nerve course; 3d, the psychical act. Hence, each feeling has a definite quality and intensity which is dependent upon the relative intensities of these three factors.

The appearance and tone of a feeling are dependent upon the condition of the nervous system. Fresh and exercised nerves are with difficulty moved to feelings. If feelings do arise, they are feelings of pleasure. It is easier to move a fresh but unexercised nerve to feelings. And much more easy to move a tired and unexercised nerve to feeling. In the last two cases unpleasant feelings are the rule.

In this connection, we must consider the attitude of the conscious states at the birth of a feeling. Here three things must be considered: 1st, a certain level of feeling already in consciousness; 2d, attention, inattention; 3d, friendliness for or opposition to the feeling.

Every bodily feeling, whatever the nature, predisposes the attitude of the body to future feelings. In general, feelings predispose us to similar feelings. In a pleasant condition, strong excitations cause pleasure; but in an unpleasant mood, the same excitation would cause pain.

It is astonishing what an important role interest plays. A man absorbed in his books is not disturbed by a cannon shot. In the heat of battle, the wounded often feel no pain.

The quality and quantity of the sensation also plays an important part in this drama. The continuance of an excitation which at first caused pleasure may turn that pleasure into pain.

According to Wundt, these feelings merge into each other through a neutral point—a point void of both pleasure and pain.

Horwicz cannot accept this view. According to him, between the feelings of pleasure and pain there is an intermediate mixed feeling. By the addition of unpleasant elements the feeling of pleasure becomes a mixed feeling. The unpleasant element gradually increases at the expense of the pleasant. Finally we have a pure, unpleasant feeling. When the excitation is not intermittent, Horwicz may be right. But in the majority of cases Kroener thinks Wundt is right.

Horwicz thinks that feeble excitations always cause pain. This cannot be true, for tickling pleases many animals and children.

Weber's law holds good for feelings as well as for sensations. Wundt gives the following example: To the possessor of one hundred thalers, the addition of one thaler gives as much pleasure as the addition of ten thalers would give to the possessor of ten thousand.

Vigorous nerve excitations produce joy. Very severe excitations produce pain. Whether a nerve is excited feebly or strongly, depends not only upon the nature of excitation, but also upon the condition of the nervous system—upon habit and exercise.

Physiology of the Sense Feeling. This is an almost unexplored field. So far the only exact data appertain to the feeling of pain. Yet we have two views upon the subject.

Weber thinks that the sense feelings rest upon a radiation in the brain of a nerve excitation. Lotze, on the contrary, thinks that the sense feelings depend upon particular feeling-engendering nerve processes.

Sometimes a person loses all feeling without a loss of sensation, and vice versa. This leads us to consider the paths ef sensation stimuli and of feeling stimuli through the myelon. In the myelon sensation stimuli follow definite tracts, while the pain stimuli spread out over the grey matter. Sectioning the lateral tracts in the cord destroys all sensation for that portion of the body which lies beyond the injury. Sectioning the grey matter in that portion of the myelon destroys all pain in the same portion of the body, This discovery is due to Schiff. Weber's theory has never received a severer blow. It was a death blow. To repeat: 1. The objective sense perceptions are conveyed only through the lateral tracts of the myelon. 2. Weak excitations of the grey matter of the cord give pleasure, while severe excitations of the same give pain.

By longer endurance or stronger excition, any sense feeling may be transformed into a general feeling. Not only this, but along with sense feelings, general feelings often arise.

It is a commonly accepted theory that the refunctioning of the same nerve elements that were active when a sensation was first experienced, will reproduce that sensation. This theory cannot be extended to the feelings. In all cases where a feeling appears to be reproduced, we really have a new feeling. The presentation which accompanied the sensation is reproduced. This arouses a somewhat similar feeling. One and the same feeling may be produced either by internal or external states.

PSYCHOLOGICAL THEORY OF THE BODILY FEELINGS. An organism is conscious of its own states. If a monera has consciousness, it has as yet no presentiment of a subject outside of itself. Its consciousness is affected only by its internal states. If it is well with it, it extends its protoplasmic arms; if it is not well with it, it contracts its arms.

In the new born child there is no sign of any psychological states, excepting that of feeling. This explains why we remember nothing of our first few hours. To remember we must have cognitive elements.[1]

The question is often asked, "How did feelings originate from sensation?" This question is unwarranted. Feelings do not arise from sensations. The question should be, how can outer stimuli be transformed within our organism into feelings of pleasure or pain?

Feeling as such does not tell us whether a thing is good or bad, beneficial or harmful. It merely says this thing makes me feel agreeably, but that thing makes me feel disagreeably.

The old adage, "whatever gives pleasure is beneficial, while whatsoever gives pain is harmful," is not altogether true. Poisons often give pleasure. Yet there is an eternal truth here. In general, pleasing things are beneficial while painful things are harmful. This fact is of great significance to the life of the individual; for all animals shrink from the painful, while they bask in the pleasurable.

Feelings stand in intimate relation so the maintenance not only of the individual but also of the species.

Thus we see that feelings play an important part in the drama of lile.

University of Cincinnati, May 6th, 1892.

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[1] Ward would not agree with Kroener. He insists that cognition, feeling, and volition are present at every stage of psychical development.

THE DORSAL ROOTS OF THE CRANIAL NERVES IN TABES DORSALIS.[1]

The author gives an interesting resume of the history of opinion regarding the dorsal columns. He says that at present there can be no doubt that Goll's columns are the continuation of the dorsal roots chiefly of the lower extremities. Flechsig divides the dorsal columns into ventral, middle and dorsal zones and also a median zone near the dorsal septum. The first to develop is the ventral, then a part of the middle and the median zones, then Goll's column and the remainder of the middle and the mesal part of the dorsal zone, and, finally, the dorso-lateral root zone.

In a moderately severe case of tabes the degeneration is most pronounced in the lower dorsal and upper lumbar regions. In the lumbar region the dorsal one-third is wholly degenerate, while the ventral third is almost unaltered. In the middle third there is a zone of degeneration occupying about the middle. At the lowest level of the dorsal cord the degeneration involves about the dorsal half. In the lumbar and sacral cord a ventral portion of the dorsal columns remains undisturbed. This area is broadest at the commissure and passes along the ventral half of the dorsal cornu, diminishing as it goes. According to Singer and Münzer, this area does not contain root-fibres, but such fibres as arise in the gray substance.

Frequently there is a small zone adjoining the dorsal fissure, which is slightly degenerated. A portion lying beneath the peripheral half of this region often is unaltered, even in severe cases of tabes. It is this portion which has been found to be affected by descending degeneration like portions of the lateral columns in a case of myelitis due to pressure in dorsal region.

Fibres arising in the sacral cord enter, not only a part of the dorsal septum but the whole dorsal periphery of the lumbar region.

The area of degeneration passes mesad as we pass to the dorsal and cervical region and becomes actually smaller. The relations are very like those resulting from compression of the cauda equina.

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[1] REDLICH, EMIL. Die Hinteren Wurzeln des Rueckenmarkes und die pathologische Anatomie der Tabes dorsalis. Arbeiten aus dem Inst. f. Anat. u. Phys. des Centralnervensystems. Vienna, 1892.

The author substantiates Westphal's localization of the patella-reflex fibres.[1]

Respecting the dorsal cornua the author concludes that in uncomplicated cases of tabes only those parts which are known to be connected with the dorsal nerve roots degenerate.

Full references to literature accompany the paper.

A Method of Making Paraffin Sections from Preparations stained with Menthyl Blue.[2]

The difficulties in the way of making permanent preparations of material stained by Ehrlich's method seem to be in part overcome by the method described. As applied to the nervous system of the crayfish, one tenth of a cubic centimeter, or less, of a 2 per cent. solution of methyl-blue was injected into the ventral blood sinus and, after fifteen hours, (the animal being kept alive meanwhile in an aquarium) the tissues were placed in corrosive sublimate. By the action of the sublimate, the blue becomes a uniform fine-grained purple precipitate. The routine is as follows:

1. Cold, saturated, aqueous solution of corrosive sublimate, for 10 minutes.
2. Solution A: methylal, 5 c.m. and corrosive sublimate 1 gr., for 15 minutes.
3. Solution B: methylal, 1 vol., solution A, 1 vol., xylol, 2 vols., for 10 minutes.
4. Pure xylol, 4 or 5 days.
5. Imbed in paraffin and section.
6. Fix with schällibaum's collodium and mount in xylol balsam.

Huber's Method of Rendering Golgi Sections Permanent.[3]

After hardening in the way recommended by Golgi and Koelliker and sectioning in celloiden under 95 per cent. alcohol, the sections were

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[1] "Das ueberall da, wo das Kniephaenomen fehlt, im Uebergang des unteren Brustmarkes zum Lendenmarke eine Zone der Hinterstraenge erkrankt sein muss, die begrenzt wird durch eine Linie, welche man sich dem hintern Septum parallel durch den Punkt gezogen denkt, in welchem die das Hinterhorn bekleidenden substantia gelatinosa nach innen zu einen knick bildet ; nach hinten bildet die Peripherie des Rueckenmarkes die Grenze "

[2] Parker, E. H. Zoologischer Anzeiger, XV, 403.

[3] Huber, G. Carl. Zur Technique der Golgi'schen Faerbung. Anat. Anzeiger, VII, 18.

brought into creosote for 15 minutes; then, after washing in turpentine, they are pressed upon the slide with filter paper and covered with turpentine balsam. The balsam is heated gently until the turpentine has evaporated, a process requiring 3–5 minutes, and then covered with a hot cover-glass. A number may be heated at the same time on a copper plate. The sections are said to remain unaltered indefinitely.[1]

THE BEHAVIOR OF THE NUCLEI OF THE SHEATH OF SCHWANN DURING DEGENERATION OF A NERVE.[2]

These interesting observations are thus summarized by Professor Huber: During degeneration of medullated fibres the nuclei of Schwann's sheath increase by mitotic division. The extension of the divided nuclei beyond the nodes of Ranvier, is apparently accomplished by active migration. The assumption by Meyer and Neumann, of free nucleus-formation, seems at least unnecessary.

The hypothesis of Schiff, Engelmann and Wolberg, that there are preformed nuclei in the Ranvier's segment which only become visible after degeneration has ensued, is also regarded as superfluous.

ATROPHY OF THE CEREBELLUM IN THE CAT.[3]

This case is of sufficient interest to warrant rather extensive quotation:

"There were but two kittens born in the litter, this cat and a sister. The latter is living and is bright and healthy. In disposition there was a slight difference, in that the subject was more shy and timid than the healthy sister, running away more quickly on the approach of strangers. Sexually, he was incompetent, his efforts in this direction being blundering and abortive. There is no history of any injury whatever, yet the trouble manifested itself suddenly, and was not progressive. Both sides were affected and were so from the very first."

"When brought to the laboratory, the cat was eleven months old. Here it was observed that he was timid and shy; well nourished; could walk and trot; but his gait was zigzag and staggering, as his hind legs

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[1] Compare DR. RUDOLF FICK. Zur Technique der Golgi'schen Faerbung. Zeitsch. f. wiss. Mik. und mik. Technique, VIII, 2.

[2] HUBER, G. CARL. Ueber das Vehalten der Kerne der Schwann'schen Scheide bei Nervendegeneration. Archiv. f. mikroskop, Anatomie, XL, p. 409.

[3] KROHN, WILLIAM O. Journal of Nervous and Mental Diseases, October, 1892.

spread somewhat laterally in locomotion; all four legs appeared somewhat ataxic, but hind legs more so; incoordination of the limbs, especially of the hind legs, which were raised very high and placed so far forward that they overstepped the forelegs in walking; peculiar movements most marked when going slowly; could jump off a stool, also raised himself on his hind legs, but manifested a disinclination toward doing so; volitional movements of the head and neck spasmodic and jerky; he trembled a great deal all the time, but especially after moving about; his sitting posture normal; shook a good deal when turning around to look out of the window; eyes also normal; tail rigid; hind legs seemed a trifle thin; miowed and purred."

"The results of the autopsy were negative save in the case of the cerebellum, which was slightly smaller and more resistant to the knife than the normal, and seemed shrunken, the cortex appearing rather thin; fore-brain in normal condition; appeared well nourished; viscera in good condition; bladder full and distended; spinal cord normal; some fat in canal; nothing to be seen in sciatic nerves. The cerebellum and spinal cord, as well as one lumbar and one dorsal spinal ganglion, were preserved for further examination and study."

"HISTOLOGY OF THE MOLECULAR LAYER. The small thread-like fibres (radial fibres) in this layer, most of which run at right angles to the surface, show much more clearly in the ataxic than in the normal, giving to this layer (in the ataxic) a marked striate appearance. Indeed, in the normal specimen, the course of the connective-tissue fibres cannot be traced, while in the diseased portions of the ataxic specimen, one can follow them as far as the Purkinje cell layer, to which their course is direct. They run parallel to each other and without dividing. At their peripheral ending, just at the pia, a few of these fibres branch, but the majority end with pyramidal bases, the broad ends of which abut against the inner surface of the pia. The Purkinje cell processes, which are much thicker than the other fibres, branch and spread, and cannot be traced to the periphery, but lose themselves before reaching the pia. These processes always divide at a short distance from the Purkinje cells, and this division occurs at a greater distance from the cell at the summit of the folii than in the region at the base of the valleys. Throughout the entire molecular layer are distributed small cells which show their nuclei very clearly. This distribution is without any order, except that the cells are more abundant in the regions contiguous to the Purkinje cell processes and near the pia at the periphery. In the normal portion of the ataxic specimen and in each of the controls, the nuclei of these cells are surrounded by a well-marked cell body, which disappears entirely in the diseased portions, leaving nothing but the bare nuclei remaining. It should also be mentioned that some of these small cells send off very fine processes, which are visible only in the normal. The processes of the Purkinje cells show much more plainly, are longer, and have more branches in the normal than in the ataxic specimen. In the diseased portions, no Purkinje cell processes are to be seen. In no case have the processes from one Purkinje cell been found to come in contact or unite with those of another Purkinje cell; they always remain distinct, even in case of the very finest processes. In the vicinity of the Purkinje cells are a few fibres that run parallel to the surface and are visible only in the ataxic specimen."

"THE PURKINJE CELLS. In the abnormal portions of the ataxic specimen, some of the Purkinje cells have disappeared entirely, leaving open and empty places, but for the most part the cells are only considerably shruken. It seems that these Purkinje cells are less affected, *i. e.*, they preserve their shape, size, and general character better in the portion of the folii near the base of the sulci than at the summits of the folii. In the ataxic, the Purkinje cells in the affected portion have lost their large round nuclei, which, with their nucleoli, show so plainly in the normal. In the normal these Purkinje cells are very similar in size and shape, while in the ataxic, there is no regularity in this respect. In all the specimens which served as controls, these Purkinje cells were found to be much more numerous at the summits of the cerebellum, where they are packed closely together, than at the base of the valleys, where they stand quite a distance apart. Small fibres extending toward the granular layer can be seen at their basal end, but cannot be followed save for a very short distance. One of the most marked differences between the tissue of the normal and ataxic specimens is that which comes out in an examination of the Purkinje cells with reference to their size, shape, and general appearance. In the normal portions of the ataxic specimen, where these cells are more like the normal, the radial connective-tissue fibres are less evident. In the degeneration of the Purkinje cells, the processes more remote from the cells are the first to be affected, then the degeneration approaches the cell itself. It begins to shrink and loses its nucleus with its shining nucleolus, as well as its elliptical shape, becoming more and more round as it becomes smaller, until it disappears altogether. All stages of degeneration were observed in the Purkinje cells of the ataxic specimen."

"THE GRANULAR LAYER. In the normal specimens the granules in the region adjacent to the Purkinje cells are larger than the others, but no structural differences are displayed. The layer of granules is always thickest at the summits of the folii, and thinnest at the bottom. There is no regular arrangement in their distribution, save that where thickest they are found in small groups. We were unable to detect any difference in the appearance of the granular layer of the ataxic specimen as compared with that of the normal, save that in the affected portions of the ataxic, the line of demarcation between this layer and the Purkinje cells is less clearly drawn, and that also in the ataxic, the granules near the Purkinje cells are oftentimes more angular in shape and, on the whole, less closely packed and less numerous in the ataxic than in the normal. The medullary fibres from the central white portion form a network throughout the whole of the granular layer."

"THE CONDITION OF THE SPINAL CORD. A few scattered degenerated fibres were found in the column of Burdach, especially in the cervical and lumbar regions, but these are restricted and apparently local, since they could not be followed in the thoracic cord.

There was no trace found of any inflammatory process, or any sort of hemorrhage, and the symptoms manifested by the cat were such that, when taken with the thinning and arrested development of the cortex, we are led to describe the disease as a case of simple atrophy, which, of course, is not an explanation. As already intimated, certain degenerations were found in the spinal cord, but in the main study these were not followed out in detail."

"(1). GENERAL CONCLUSIONS. The general fact, so well sustained by measurements recorded in the table, that in the normal specimens the molecular layer of the left hemisphere of the cerebellum is thicker than that of the right hemisphere. In only five instances was there a preponderating thickness of this layer on the right half, and since, in the characteristic cat's cerebellum, the vermis is turned rather to the right of the middle line, these exceptions might readily be accounted for."

"(2). A marked growth in the thickness of the molecular layer of the six months' cat, as over against the one three months old, is also indicated in the table. Thus the average thickness of the entire molecular layer in the case of the three months' cat is about .286 of a millimeter, while while that of the six months' cat is .333 of a millimeter, an increase of 16½ per cent."

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"(4). It will be remembered that the ataxic kitten was three months old when it began to manifest symptoms of disease. But, by reference to the table, it is seen that the molecular layer is much thinner in the case of the ataxic cat than in the normal three months' cat."

"Arrested development alone cannot account for this. It is only explained by an active atrophy."

"(5). The distribution of the Purkinje cells. It is an interesting fact in every normal specimen examined, the Purkinje cells were closely packed together at the summits of the convolutions, where they were found to be very numerous, while at the sides, as we passed toward the base of the sulcus, the distance between these cells was found to increase, and at the very bottom they stood quite far apart. This makes a direct proportion between the thickness of the granular layer and the number of Purkinje cells, as has been already suggested by others."

"(6). Certain histological characteristics. (*a*) Some sort of relation exists between the peripheral processes of the Purkinje cells and the small cells of the molecular layer, but this is only of a general nature. (*b*) In the degeneration ef the Purkinje cells, the processes more remote from the cells are the first to be attacked, then this degeneration approaches nearer and nearer to the cell-body, which begins to shrink, losing its nucleus, becoming smaller, until it drops out altogether, leaving an empty cavity."

EXPERIMENTAL ASCENDING DEGENERATION.[1]

After section of a peripheral nerve, medullary sheath and axis cylinder decompose and disappear. The nuclei of the sheath of Schwann at first multiply and then likewise disappear, leaving of the sheath only a fibrous cord. These degenerative processes are explained by the theory that the central organ exerts a trophic function, of which the part peripherad is deprived by the section.

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[1] BREGMAN, E. Ueber Experimentelle aufsteigende Degeneration motorischer und sensibler Nerven. Arbeiten aus dem Institut f. Anat. u. Phys. des Centralnervensystems. Vienna, 1892.

In conformity with this hypothesis it has been claimed that degeneration does not proceed centrad in the case of centrifugal nerves.

The investigation of the central system of those who had suffered amputation, showed that changes actually go on in the central stump and cord. Vulpian was the first to investigate the effects many years after amputation. He found considerable diminution in the size of the corresponding half of the cord, especially in the segment from which the nerves arise. Vulpian recognized simply a thinning without histological alteration of the nerves, and in the cells there was nothing abnormal. Dickson, Hayem, and others noticed diminution in number of the cells of the ventral cornu and obvious indications of degeneration. Friedländer and Krause state that it is only in the lateral group of the ventral cornua that this diminution takes place and especially call attention to the reduction of dorsal columns and cord and loss of cells in Clark's columns. It was concluded that the effects are due directly or indirectly to degeneration in the sensory paths.

The experimental researches of v. Gudden and his school have added much to the solution of these problems. The method consists in the eradication of nerve roots in new-born animals.

Meyser removed the sciatic nerve with its spinal ganglia and noticed reduction of the gray matter, especially of the dorsal cornu. The ventral cornu lost its definite boundaries and exhibited obvious degeneration phenomena.

Removal of the seventh nerve produced atrophy of the lower facial nidulus. Eradication of the nerves of the eye muscles produced atrophy of the niduli of III, IV and VI, while section of the XII nerve destroyed the large-celled hypoglossus nidulus, but not that of Roller.

The vagus has also been operated on with more or less definite results. [See Vol. I, p. XXVI.]

Even in adults, as Nissl has shown, 24 hours after eradication of the facial, histological changes occur in the cells of its nidulus. The chromatin body decomposes in part of the cell. After six days the protoplasmic structure is lost. [For recent studies see Vol. II, p. liii.]

The author's work may be thus summarized:

Out of six cases where the facial was removed, every root fibre degenerated on the operated side. There is no evidence of a partial decussation of this nerve. The fibres connecting facialis and raphe do not degenerate.

While the author does not go to the extent which Forel does in claiming that the degeneration is similar in nature in the sensory and motor roots, he thinks loss of function is chiefly responsible for the degeneration of motor roots and that the alteration first appears in the cell and afterwards affects the fibre.

It was also found that pulling out the facial causes degeneration in the corpus trapezoides. This is perhaps due to mechanical injury, as simple section of the nerve does not produce the same result. Section of the trigeminus by means of a neurotome after Magende's method, though difficult, was carried out. Both the sesory (major) and motor (minor) portions were found degenerate. In the ascending root the degeneration could be followed into the cervical medulla. The median portion of the portio major corresponds to the ventral part of the ascending root and the lateral part corresponds to the dorsal part of that root. Only few fibres seem to come from the sensory nidulus.

The motor root (minor) was degenerate in all cases where the third ramus was cut. The tract passes dorsad and somewhat cephalad. The descending root (from the giant cells over the aqueduct) was always degenerate. The author regards these as motor, because of their connection with the portio minor.

Injury of the pyramidal tracts caused descending degeneration as far as to the decussation, but nothing definite could be followed in the cord.

The partial crossing of the oculomotor fibres, described by v. Gudden, is substantiated. The paper is accompanied by three lithographic plates.

THE ROOTS OF THE TRIGEMINUS.[1]

These observations were made on the human fœtus and lower animals, chiefly by the method Weigert-Pal.

The ascending root fibres appear at the level of the second cervical nerves by an increase in the volume of the gelatinous substance and the fibres on its mesal margins. The latter pass cephalad and then arch laterad, passing through the substantia gelatinosa, and form the ascending root on the lateral margin of the gelatinosa. This arching outward of the fibres continues to the level of the sensory nidulus of the trigeminus.

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1. POMIRTOWSKI; A. Ueber die Trigeminuswurzel im Gehirne des Menschen, nebst einigen vergleichend-anatomischen Bemerkuugen. Arbeiten aus dem Inst. f. Anat. u. Phys. des Centralnervensystems. Vienna.

It is unquestionable that these fibres pass through the gelatinosa without coming into closer relation with it. The real origin is the grey substance of the dorsal cornu. In birds and fishes the dorsal fasciculus seems to contribute a large contingent to the root. [This we think is a mistake so far, at least, as fishes are concerned. Ed.] What the relation of the gelatinosa is was not determined.

The bundle of the median line. In this group of fibres authors have distinguished (1) those from the motor and perhaps also the sensory niduli of the opposite side; (2) fibres of the peduncles connecting with the cerebrum; (3) cells from the locus cœruleus either with or without decussation in the raphe. The greater part of the motor root arises in the motor nidulus of the same side, the remainder cross through the raphe to the other side.

The *crossed descending bundle* has no connection with the locus cœruleus cells. It is sensory and has small fibres. Other fibres of the crossed bundle seem to pass to the cerebrum.

The *descending bundle* is shown to be of motor nature.

The author denies the existence of a cerebellar tract. [The present writer agrees with the author that Edinger's statement that the greater part of the trigeminus bundle in fishes arises in the cerebellum, is incorcorrect.] The constituents of the sensory root: (1) the ascending bundle, arising in caput and cervix cornu dorsalis; (2) fibres from the sensory nidulus of the same, and (3) those of the opposite side.

The constituents of the motor root: (1) fibres from motor nidulus of the same, and (2) of the opposite side; (3) the descending tract.

ELECTRICAL ANÆSTHESIA.[1]

The author formulates the opinion that all forms of localized pain, not dependent upon structural changes of nerves or nerve centres, or destructive metabolism of other tissues, may be relieved promptly and effectively, and often cured, by an induced electrical current, whose interruptions are sufficiently frequent and whose strength is small. He found that blows of a small hammer weighing ten grains, repeated as often as 400 times per second, did not produce the desired effect.

[Experiments made long since by the writer show that a much less number of vibrations, if so imparted as to involve the whole number, *i. e.*

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[1] HUTCHINSON. W. F. Electrical Anæsthesia by means of the singing rheotome. New England Medical Monthly, XII, 2.

so as to agitate the nerve trunk as well as the skin, will produce numbness.]

Subsequently the author found in the tuning rhetome an available means of applying intermittent electrical stimuli.

Anæsthetic effects were produced by 540 vibrations (C major) but if the vibrations ascended above D axacerbation of the pain resulted. The practical application to minor surgical operations and neuralgia seems valuable.

[The reason why the more rapid notes fail of anæsthetic effect, may be that the wave length of nervous excitement is such that more rapid excitement causes the waves to fuse, resulting in general hyperæsthesia of the fibre. Some experiments carried on by the writer's students seem to show a great variability in the upper limit at which vibratory stmuli may be recognized.] We are promised special apparatus for this purpose.

SOME REMARKS UPON THE EYES OF SALPA.[1]

The eyes of salpa are situated upon the dorsal surface of the brain and have been differentiated from it. In the simplest case, the eye is represented by a single dorsal swelling. The major portion of the swelling is composed of the retina, the elongated cells of which constitute the whole of the dorsal surface of the eye. These cells occupy a single row, and their longitudinal axes are perpendicular to the surface of the eye. At the base of this swelling there is a girdle of pigment cells. Both the pigment cells and the retinal cells have been derived from the ganglion. Here, as in all Salpidae, the retina contains two kinds of tells, "sehzellen" and "stutzzellen." The "stutzzellen" form a sort of framework in which the "sehzellen" are imbedded. During life the "stutzzellen" are, probably, pigmented. In this simple case the retina cells are situated between the nerve fibres and the surface.

The change that has taken place in more complex eyes can be best understood by a study of the horse-shoe shaped eyes. The central portion of such an eye consists of a simple dome-shaped eye similar to the one just described; but the lateral arms are quite different, At we pass towards the extremity of such an arm, we find that the retinal cells have rotated more and more latero-ectad until, finally, they are perpendicular to their original position. During this rotation the nerve-fibres have

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[1] BUETSCHLI, O. Einige Bemerkungen ueber die Augen der Salpen. Zool. Anzeiger, XV, Jahrg, s. 349.

been carried to the surface. Thus we have the originally simple eye divided into three portions: one central portion, in which the retinal cells are superficial and two lateral portions in which the nerve-fibres are superficial. The central mass is a simple eye and the two lateral masses are inverted eyes. In some species of salpa these three parts are separated, forming three eyes situated upon the anterior end of the brain.

The author thinks these facts have a deep morphologico-phylogenetic bearing. He thinks they make it less difficult to harmonize the simple uninverted eyes with inverted ones. He proceeds as follows. To homologize the simple eye described above with the bladder-like eye of the tunicates, he supposes that all observers (himself included) have overlooked a flat layer of cells which cover the retina and which are continuous with the pigment cells. If this hypothetical membrane exists, then the lateral inverted eyes derived from such an eye would also have an investing membrane. If this be true it is possible to give a morphological explanation of the formation of the eye-ball. At the time of the formation of the lens let the retina and the pigment layer of the originally flat, bladder-like, inverted eye grow upward and form a cup-shape body. Let this cup be plugged by the crystalline lens and the major part of the work is done. The author thinks that there is nothing improbable about this supposition.

THE COMPOSITION OF THE CEREBRO-SPINAL FLUID.[1]

The author finds that the fluid is more strongly alkaline in the early morning than at night and that the solid elements of the blood are in greater amount in the morning. This fluid is more slowly affected by substances introduced into the body than the general circulation, urine, or humors of the eye. The results are thought to substantiate Obersteiner's theory of sleep.

THE PARIETAL NERVE.[2]

Abstracted for this journal by Mr. L. H. CAMMACK.

In the October number of the "*Anatomischer Anzeiger*," Prof. Bèraneck has given a very complete and scholarly paper, containing his ar-

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[1] CAVAZZANA, E. Ueber die Cerebrospinalfluessigkeit. Centralblatt f. Physiologie, VI, 14.

[2] Sur le nerf parietal et la morphologie du troisiememe œil des Vertebres, Anat. Anzeiger. VI, 21-22.

guments for the existence of a third eye in Vertebrates. He combats especially the opinion expressed by Leydig that the cells of the pineal are lymphatic vessels, and gives numerous proofs for the sensory character of these cells.

In spite of numerous researches, the histological structure, the function and the origin of the parietal organ is yet wrapped in mystery. Most authors grant that it has at some time played the role of an eye. Its optical characteristics however are greatly diminished in the actual specimens. It is in direct relation with the epiphysis and is considered by many as merely a differentiation of this organ. Leydig has raised serious objections to considering it as an eye at all. He attributes lymphatic rather than sensory functions to the parietal organ. Does Leydig sufficiently establish his position? I think not. The pineal eye is an organ on the way to degeneration. It is not strange then that it has not preserved the impress of its optic characteristics. The question is not whether, in the retina of the third eye, ganglion cells and cones have been found, but whether, taken as a whole, its characters ally it more with vsual organs or not.

Leydig argues that no nerve serves the parietal organ. If it has served as a visual organ the nerve ought to remain. But no nerve being left proves that it never served the purpose of sight. He asserts that the formation designated by Strahl, Martin, Francatte and others under the name of parietal nerve, is either of a connective or vascular nature.

Spencer finds in Saurians a nervous cord enclosing nuclei drawn out and attached again to the pineal eye at the epiphysis. Leydig refuses to see a nerve in the epiphysal cord of Spenser, but considers this formation as terminating in the mesodermic lamina surrounding the pineal. In the *Anguis fragilis* I have discovered a slender bundle of fibrils starting from the intermediate brain (diencephalon) in front of the base of the epiphysis and ending in the retina of the parietal organ. I liken this bundle to a nerve, but cannot yet trace it definitely to its point of origin. Strahl and Martin and Francatte have asserted the existence of a pineal nerve independent of the epiphysis. The pineal eye is situated in the region of the plexus choroideus and is often enveloped with a vascular net-work. One of these vessels, passing under the optic vesicle and penetrating between the plexus choroideus and the epiphysis, I have been able to follow exactly, both in its origin and passage, and it is not to be confounded with a lymphatic vessel, since it does not possess the histological characteristics of one.

The last of the parietal nerve arises in the roof of the diencephalon, between the origin of the epiphysis and the first fold of of the plexus choroideus. It is there completely independent of the pineal gland. It springs from a little mass of nervous cells. Its relations with the encephalon, its fibrillary character and the absence of an *endothelium* prove it to be a nervous structure. During all its course the nerve remains independent of the pineal gland. It is pale and translucent, permitting the mesodermie layer to be seen below it. It is transitory and on the way to atrophy. It is seen in the embryo but disappears in the adult, and does not appear at all in very many specimens,

"I cannot subscribe to the opinion of Francatte, when he holds that there is a cellular cord in contact with the pineal eye in one hand and the epiphysal body on the other, which represents the last trace of the union between the individualized parts of the pineal, becoming the nerve of the third eye. I hold that the parietal nerve is completely independent of the epiphysis. It receives no fibril springing from the epiphysal body. In the embryo of the *Anguis* of 15 m.m. the epiphysis is very oblique with reference to the parietal eye and rests against the posterior face of the latter. The optic vesicle is a little distant from the diencephalon. Its inferior face, opposite the encephalon, presents a little cellular mass. This mass is the first indication I have observed of the future parietal nerve. It is entirely independent of the epiphysis.

"The results of my observations permit me to draw the following conclusions :

"1st. There exists in *Anguis fragilis* a parietal nerve which arises from the arch of the diencephalon and ends in the pineal eye. It is not a lymphatic vessel, for it is not tubular nor limited by an endothelium and it has a fibrillary structure.

"2. This nerve is not derived from or dependent on the epiphysis, but from its first appearance binds the pineal eye to the encephalon.

"3. The nerve is transitory, making its first appearance in the embryo of about 15 m.m. and disappearing at a stage between 55 and 60 m.m. in length.

"In *Lacerta agilis* the parietal eye does not proceed from an ulterior differentiation of the distal extremity of the epiphysis, but the two organs develop coetaneously at the cost of two evaginations of the intermediate brain. These are arranged one above the other and detach themselves from the same cerebral region. This mode of formation seems to me to speak in favor of a distinct genesis of two cephalic diverticules represented, the anterior the parietal eye, the posterior the epiphysis. The presence of a nerve independent of the epiphysis is very strong proof for the individuality of the parietal organ. The authors which have described more parietal organs have probably considered as such the *paraphyses* of Salenka.

"There are in the embryos of Saurians three encephalic diverticles; of these three a single one, the parietal organ, has played a sensory role. These diverticles are not differentiations of the encephalon at the same phylogenetic period. The visual functions of the parietal eye are atrophied at the same time that the dermic ossifications take on in the cranial region a greater importance, and that the encephalon removes further from the ectoderm. This eye is found among fishes, reptiles and also among amphibians. It is rudimentary among the Teleosts.

The ontogeny shows that the third eye appears after the closing of the cephalic region of the medullary tube. It proceeds entirely from the encephalon and swells into an optic vesicle, the dorsal wall of which constitutes the crystalline humor of it and the ventral, the retina.

But what has been the role of the parietal eye and why was it developed?

Eycleshymer answers this by saying that in the closing of the medullary tube the equal or regular eyes—before this influenced directly by the light—lost more or less completely their function. This loss of functional activity was compensated for by the appearance of an azygos dorsal eye which commenced to atrophy as soon as the two equal eyes began to regain their preponderance.

The conclusions which proceed from my review are as follows:

1. The parietal cannot be considered as a simple diverticle of the pineal gland. In the Lacerta and Anguis it is a separate organ developed with and yet independent of the epiphysis.

2. This eye is supplied by a bundle of transitory nerves not connected with the epiphysis. It arises from a little cellular mass situated between the base of the pineal gland and the fold of the plexus choraideus.

3. The odd eye is an evagination from the dorsal wall of the intermediate brain and constitutes a continuous optic vesicle. It shows itself relatively late in its embryological evolution and cannot be invoked as a proof of the duality of origin of the parietal organ.

4. The azygos eye is not met with among the chordata. It is an ancestral eye which has disappeared in many of the actual forms. The primitive optic vesicle is still recognizable among the Cyclostomes and Saurians; it is rudimentary in the Teleosts.

5. The epiphysis is also derived from an evagination of the intermediate brain; it does not represent the optic pedicle of the parietal eye. It does not reveal optic characteristic even among the Selacians in which it is highly developed.

6. The azygos eye and the epipysis appertain to the diencephalon; the paraphysis depends upon the anterior brain of which it is nothing more than a diverticle. This paraphysis does not show optic characteristics in any phase of its developments. It gives birth to one or more secondary vesicles in the epitelial walls which cannot be confounded with the parietal eye.

7. Of the three encephalic diverticles so marked in Saurians the parietal organ is the only one that has certainly had sensory functions.

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The Messrs. Macmillan & Co. announce that the recently completed edition of Foster's Text-Book of Physiology in four parts is to be supplemented by the issue of an appendix on "The Chemical Basis of the Animal Body," by A. Sheridan Lea, Sc. D. F. R. S. Dr. Lea is Lecturer on Physiology to the University of Cambridge, England.

LITERARY NOTICES.

DEGENERATION OF PERIPHERAL NERVES.[1]

In 1795 Cruikshank divided the vagus-sympathetic nerve trunk in the neck of a dog and found that, when the section was performed on both sides, death followed very promptly, while a unilateral section was not fatal. He then divided the nerve on one side and, after an interval of three or more weeks, cut the other. The animal survived, thus showing that the severed trunk had meanwhile united. This experiment seems to have been the starting point for a long series of research upon. the nature of the dependence of nerve fibres upon nerve centres, which have culminated in the masterly monograph before us.

Flourens (as it is claimed) succeeded in suturing the cut ends of the median and ulnar nerve, each to the stump of the other. Functional union was effected and stimulation of the dorsal nerve caused motion of the ventral peripheral muscles and *vice versa*. Since Flourens' time the fact that a severed nerve may again become functional has been repeatedly demonstrated, but it has not been so easy to determine whether the union was preceeded by a degeneration and regeneration of the entire peripheral portion. The histological problems involved, *e. g.* whether the axis cylinder repenetrated the sheath from the stump, have remained unsolved.

When the nerve is cut and the stumps not reunited or sutured, every one admits that a process of degeneration follows. Beyond this there is little unanimity. All admit that the myelin disappears, but Neumann, Eichhorst, Mayer, etc., suppose that the myelin simply suffers transformation and forms the material of the new sheath in case of regeneration. While some describe the process of degeneration as beginning at the proximal end, the majority recognize the process as coetaneous through-

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[1] HOWELL, W. H. and HUBER, G. C. A Physiological, Histological and Clinical Study of the Degeneration and Regeneration in Peripheral Nerve Fibres after severance of their connections with the nerve centres. Journal of Physiology, XIII, 5, 1892.

out the peripheral portion. Earlier writers suppose that the axis cylinder remains intact. Neumann and Eichhorst believe that it suffers transformation without actually disappearing, but most writers describe its disappearance with the sheath structures. The belief that a nerve fibre is an outgrowth of a cell in the central system (often several feet long!) has contributed to produce a predisposition to a belief in the degeneration as a result of trophic disturbance. Great difference of opinion exists as to the possibility of a union by first intention. Some cases in which, after suturing a nerve, there was almost immediate restoration of function seem to sustain such a view.

The paper above noticed contains abundant historical matter and a full list of titles. The work of the authors themselves has been largely experimental, but in all cases the results have been elaborately checked and enlarged by histological investigation, thus giving to the results obtained a degree of precision which cannot be too highly commended. Dogs were used in the experiments and the ulnar, or ulnar and median nerves were selected. Operations were carried on with antiseptic precautions and the nerve fibres were sutured with carbolized catgut or catgut in juniper oil. Two sutures were used, one on each side, the needle being passed through the epineurium. Continuity of the nerve was destroyed by section with sharp scissors, crushing by a ligature, or coagulation by means of a current of water at 80 degrees C. passing through a curved glass tube. Morphia and ether were employed as anæsthetics. The testing stimulus was a unipolar electric current, the indifferent electrode being applied over the skin of the sternum. In some cases a small block of hard rubber was passed under the nerve and a direct impact employed as stimulant.

1. In none of the cases was there union by first intention, the peripheral end degenerating throughout its whole extent.

2. The time necessary before loss of irritability and conducting appears, varies greatly (between 2 and 4 days.)

3. The return of function readily but gradually takes place if the ends are primarily sutured.

4. The irritability returns first in the vicinity of the wound. It only returns when regeneration has proceeded so far that some medullated fibres are present.

5. The return of function takes place more quickly in sensory than in motor fibres. This is explained by the authors as due to the greater

difficulty of affecting connections (in the end-plates of muscles, for example.)

6. Light mechanical stimuli were often more effective in exciting the fibres in an early stage of regeneration than electrical induction shocks. [May this not be due to the greater autonomy of the segments and the functional activity of the local elements during this stage?.—ED.]

7. Conductivity is restored before irritability; but these embryonic fibres respond to mechanical impulse when not to electric shock. [See remark above.]

8. The possibility of the functional union of two spinal nerves was proven. The central end of the median was united to the peripheral end of the ulnar nerve and the peripheral stump of the median and the central stump of the ulnar were dissected away. Functional union occurred and the animal was examined after 75 days. The physiological results of the union were unfortunately poorly differentiated.

In the histological study the best results were obtained by the method of teasing. The fresh nerve was pinned out, hardened and stained in osmic caid 24 hours, then washed in water 24 hours or six to seven days. Next it was partially teased, stained in Bœhmer's hæmatoxylin and examined by teasing on the slide in glycerine or Farrant's solution. Other nerves were hardened in Mueller's fluid, then, after partial teasing, were stained by Freud's potash-gold method and treated with hæmatoxylin for nuclei. This method brings out the axis cylinder. A third method is recommended, which consists in pinning out in picric acid, saturated solution, 48 hours. They were then washed out in water 5 or 6 hours and subsequently in 33 and 50 per cent. alcohol and preserved in 95 per cent. They were then partially teased and stained 10-15 minutes in Bœhmer's hæmatoxylin The process seems to expose the axis cylinder by removal of the myelin.

"After the interruption of the connection between a nerve fibre and its centre, whether the interruption be by actual section, by crushing, or by coagulation, the peripheral end of the fibre undergoes degeneration, the changes affecting first the myeline and the axis, and subsequently the sheath and its nuclei." The degeneration begins, in the dog, after about 4 days. The fragmentation of the myelin sheath (at the lines of Lantermann) is regarded as independent of and prior to the increase of protoplasm about the nuclei. The axis cylinder breaks up with the myelin and remains enclosed within the latter. These changes take place substantially cotemporaneously throughout the peripheral end. A secondary fragmentation occurs first in the vicinity of the nuclei. By the seventh day there is active proliferation of the nuclei. After subdivision the nuclei migrate and set up new centres of absorption.

Regeneration begins with the formation of new protoplasm about the nuclei, which then assume the form of bipolar cells; at a later period the whole sheath is filled with a continuous belt of protoplasm in which the nuclei are imbedded. Such a fibre is called an embryonic fibre by reason of its resemblance to the early condition. In some cases it appears that two new fibres may be formed in one old sheath.

In case the cut ends are not united, regeneration never gets beyond the embryonic stage. If united the myelin is formed discontinuously, generally near the nucleus, subsequently uniting to form a continuous sheath. Respecting the nuclei, the authors are not clear. They suppose that they disappear by absorption.

"With reference to the nodes and internodes of Ranvier, it is evident that no simple hypothesis, such as the development of each internode from a single cell, will fit the facts as they appear in regenerating fibres." They admit that the internodal nucleus must, throughout life, play an important part in the nutrition of the protoplasm in connection with it and of the myelin sheath. "In an indefinite way we may suppose that this nutritive influence on the myeline can only extend over a limited area—the distance of an internode,—but to connect this with the formation of these internodes takes us into the field of speculation, though it seems to us that the true explanation lies along this line of thought. The origin of the segments of Lantermann may doubtless be traced directly to the primitive, disconnected deposits of myeline which we have described." The authors seem to believe that the axis cylinder proceeds from the stump into the newly formed myelin, a position rendered very improbable by their figures.

"In the central end, especially when connection with the periphery is not made, several new fibres may form within the sheath of an old one to take the place of the portion degenerated. Each of these may develop myeline and receive a branch from the axis cylinder above."

The paper is a credit to American science and it is a great pity that it should not have found an American medium of publication. The plates are exceedingly instructive.

We cannot forbear adding that the obvious influence of a strongly supported histogenetic hypothesis has been a serious detriment to the theoretical portion of the work. Even our elementary text books teach that the peripheral nerves are formed as the outgrowths of a single central cell. Such outgrowths being, accordingly, in some cases, several feet long (Martin's Human Body.) So far as can be gathered, this is pure assumption and is inherently very improbable. Study of the growth of nerves in embryos of serpents, amphibians and mammals, has convinced the writer that, in some cases at least, the growth is by moniliform adhesions of neurons. The process is essentially the same as that occurring in the tracts of the cord where the longer reaches of tracts are in like-manner thus formed. When definite functional paths are formed the nuclei are relieved of part of their function and a variety of subsidiary processes resembling fatty degeneration occur, and in this way sheaths are formed. The case of the olfactory is therefore simply a striking illustration of the normal process which is less clearly seen elsewhere. If this be accepted, it may be admitted that the effect of a proliferating nerve upon the developing adjacent tissues may for a time be less dependent on the central than the peripheral neurons.

It is not a little strange that a second work covering the same ground, with similar methods should appear at nearly the same time.[1]

This paper was awarded the medical prize of the Faculty of Würzburg University for 1891.

The author's summary is substantially as follows: After an injury to a peripheral nerve destroying its substance at any point, the entire peripheral portion, as well as a short part of the central stump, degenerates. Healing by first intention does not occur. The degeneration of the immediate vicinity of the wound is followed, 48 hours after, by a paralytic degeneration of the peripheral part, which is due to various causes. The axis cylinder gives up fluid and grows smaller, Its shrinking produces fragmentation of the sheath. The contraction of these fragments produces a corresponding rupture of the axis. At about the fourth day the nuclei of Schwann's sheath begin to proliferate and the protoplasm increases, which process perhaps assists in the degeneration. The

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[1] NOTTHAFFT, A. F. N. Neue Untersuchungen ueber den Verlauf der Degenerations- und Regenerationsprocesse am verletzten peripheren Nerven. Zeitsch. f. wis. Zool., LV, 1. Nov., 1892.

degenerating medullary sheath leaves a fluid in the sheath which is gradually absorbed. There is not a fatty degeneration of the medullary sheath, though infiltration of fat in adjacent structures cannot be denied. Neither is there a chemical transformation in the sense of Neumann and Eichhorst. Leucocytes have nothing to do with the degeneration, and Ranvier went too far in ascribing it solely to the proliferation of the nuclei. The axis cylinder decomposes before the medulla and sheath. The degeneration passes with marvelous speed from the site of injury peripherad.

The proliferating nuclei of Schwann's sheath seem to facilitate the degeneration and regeneration, but neither they nor the increased protoplasm have anything to do with the formation of the axis cylinder. Bünger's protoplasm bands are probably simply folds in Schwann's sheath. There is no reason to doubt the statements of Koelliker as to the consistency of the axis cylinder and the connective nature of the sheath. The axis cylinder grows from the central stump continuously. The new fibres appear in 8 or 10 days. In some cases the medullary sheath is not at once formed. Nerves caused to degenerate by crushing do not form more than a single fibre in a sheath. The new Schwann's sheath is apparently formed by the nuclei of the old sheath.

To judge from the drawings there is much reason to suspect that a better interpretation would show an intimate connection between the nuclei of Schwann and the axis cylinder, which latter is jointed in a way suggestive of moniliform concresence.

The Cerebrum of Reptiles.[1]

This extensive paper by a young physician recently Americanized contains promise of good work, but fails of adding materially to our knowledge by reason of ignoring previous writers and the crude methods employed. The terminology is that of Edinger. Brains hardened in Mueller's fluid and stained with analine cannot be expected to yield histology. The differentiation of cells seems to have been imperfect, but the difference between the pyramidal and fusiform cells of the various areas were made out. Although special attention is given to the snake brain we find no mention of the remarkable peculiarities of the tuber with its lateral pero and olfactory fossa and no recognition of the relation

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[1] Meyer, A. Ueber das Vorderhirn einiger Reptilien. Zeitsch. f. wiss. Zool. 1

between pero and pes. Although strongly criticising the misuse of anthropotomic terms he employs septum and nucleus sphericus contrary to the law of priority.

It is hoped that the author may continue his studies and extend the present publication, which will be critically discussed in another place.

IS THE RETENTION OF URIC ACID PATHOGENETIC OF NERVOUS DISEASE?[1]

This paper contains much of great value to the physiologist and pathologist. The methods of determining uric acid and urea, physiological variations in the excretions, quantitative relations of urea and uric acid in health, influence of drugs, etc., are treated critically as preliminary to the question of the excretion of uric acid in disease.

The authors devote considerable space to the criticism of Haig's theories that certain kinds of food render the blood less alkaline and thus occasion a storing up of the uric acid (which is more soluble in an alkaline solution) in the tissues. When the blood becomes more alkaline an excess is thrown into the blood, producing migraine headache, epileptic paroxysm or mental depression. A general criticism of this view rests on the scantiness of evidence adduced. The theory of storage of uric acid is regarded as inherently improbable. The authors observe increase of uric acid excretion in chorea, proportional to the severity of the attack. With respect to epilepsy the authors say, "We may, however, say that we have as yet obtained no grounds for the view that the *grand mal* paroxysm of idiopathic epilepsy is regularly or even usually preceeded by diminished uric acid excretion."

The increase follows the paroxysm, being often greatest on the second day, which fact may be supposed to suggest that the uric acid increase is due to conditions associated with, or perhaps occasioning the attack. *Petit mal* cases exhibit a large and persistent excess.

Paroxysmal vomiting in children is often followed by a very remarkable increase and migraine shows a considerable increase. It is concluded that the increased execretion is an effect of numerous different derangements of nitrogeneous metabolism.

A second paper by the same authors[2] discusses these questions fur-

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[1] HERTER AND SMITH. Observations on the Excretion of Uric Acid in Health and Disease. N. Y. Med. Journ., June 4, 1892.

[2] Researches upon the Aetiology of Idiopathic Epilepsy. N. Y. Med. Journ., Aug.-Sept., 1892.

ther and seems to indicate some connection between intestinal putrefaction and epilepsy. The evidence on this head is interesting but far from convincing.

EXCISION OF CORTEX AS A CURE FOR INSANITY.[1]

Six cases of chronic mania, dementia, etc., were operated by removal of 2 cm. or more of the cortex, the areas corresponding to the seat of the sense chiefly affected by hallucination. In five cases, amelioration, in one, death resulted. The effect seems to consist in the transformation of impulsive mania into passive dementia, frequently with removal of the hallucinations.

JAMES BRIEFER COURSE IN PSYCHOLOGY.[2]

Professor James is a teacher, and his much used work is conceived as only a teacher could. It contrives to supply very much of the vivacity and piquancy of personal instruction within the compass of a text book. Add to this the fact that he is especially alive to the prevailing tendencies in psychological thought and we have a partial explanation of the sudden success of a work which is neither logical in arrangement nor faultless in psychical analysis. The briefer course seems to us a vastly more usable book. The author describes it as three-fifths "scissors and paste." These three-fifths have greatly gained, from the student's standpoint, through both these modifying agents. The scissors have relieved him of tapestries which would, in all probability have hung in shreds about his hurrying feet, and the paste has been "mixed with brains." The two-fifths not accounted for supply important physiological details as to the sensory organs which American classical courses seem never to adequately supply in the term or two of physiology.

Many teachers will object to building up the fabric of an elementary text-book upon such a 'working hypothesis' as this: "Mental action may be uniformly and absolutely a function of brain-action, varying as the latter varies, and being to the brain as effect to cause." Conscious processes are divided into sensation, cerebration, and tendency to action.

The paragraphs on sensation fail to distinguish adequately sensation and perception. Especially unsatisfactory is the discussion of externali-

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[1] BURKCHARDT, G. Allg. Zeitsch f. Psychiatrie, XLVII.

[2] JAMES, WILLIAM. Psychology. American Science Series. Briefer Course. Henry Holt & Co., New York, 1892.

zation and excentric projection. The author claims that "the very-first sensation which an infant gets *is* for him the outer universe." "The object which the numerous impouring currents of the baby bring to his consciousness is one big, blooming, buzzing confusion. That confusion is the baby's universe." Many such expressions make us wish that the author could have escaped from some of the consequences of the contact with American tendencies which nevertheless impart the breeziness of style which compel almost unwilling admiration. The chapter on the structure of the brain, supplemented by that on its functions, gives a synoptical sketch of the neurology, and it is the teacher who says, with a sigh perhaps, "When is all is said and done, the fact remains that, for the beginner, the understanding of the brain's structure is not an easy thing. It must be gone over and forgotten and learned again many times before it is definitely assimilated by the mind."

The chapter on habit is full of useful maxims. Many will gratefully agree that "the traditional psychology talks like one who should say a river consists of nothing but pailsful, spoonsful, quart pots full, barrels full and other moulded forms of water;" and accept with such grace as he may the conclusion that "each of us dichotomises the Kosmos in a different place."

The chapter on attention is especially good. James adopts (with regret) the terms recept (or construct) and isolate of comparative psychology. He goes the full length of Professor Bain in assuming that all consciousness is motor according to a law of diffusion. "A process set up anywhere in the centres reverberates everywhere, and in some way or other affects the organism throughout, making its activities either greater or less." James follows Lange in asserting that "bodily changes follow directly the perception of the exciting fact and that our feeling of the same changes as they occur *is the emotion*." While not wishing to belittle the physical concomitants in emotion, we protest that it is a pity to strip these important sections of our psychical life of their cognitive elements. It seems to us that James has fallen into an error analogous to those against which he has warned us. In classing emotions as a variety of impulses, as in the earlier work, he prepared the way for this error. A more natural order is here followed, viz: (1) Expression of emotion, (2) Instinctive or impulsive performances. (3) voluntary deeds. We object to identifying emotion with either its expression or physiological element. No doubt many emotions are due to reflexes producing total sensations, but such sensations have this as a characteristic that they implicate the empirical ego, and that act of cognition which forms the nexus between the physical shock and the subject of consciousness can no more be left out than the data of effort can be left out of perception.

The chapter on will is quite a full reproduction of that in the larger work and is so suggestive that no attempt can be made to discuss it here. The work has that prime requisite of a text book, it is suggestive and fresh and does not leave the student with the deadly delusion that he has finished the subject.

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DECEMBER, 1892.

DECEMBER, 1892. [Supplement.]